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Columbia River Drainage In Montana

WATER POLLUTION CONTROL

Report No. 59-1

STATE BOARD OF HEALTH

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SURVEY REPORT

Prepared by

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Edited by

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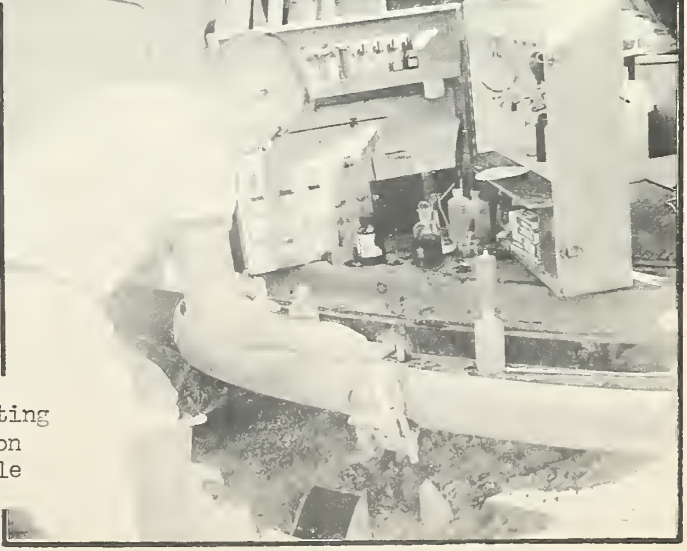
DIVISION OF ENVIRONMENTAL SANITATION
MONTANA STATE BOARD OF HEALTH

Engineer and biologist sorting bottom fauna collections



Chemist conducting pH determination on water sample

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*Assigned by the Fish and Game Department at time of this survey.

FOREWORD

With the passage of a revised Water Pollution Act by the 34th Legislative Assembly in Montana in 1955, it was recognized that recreational, industrial and agricultural uses of Montana's waters, in addition to previously recognized health uses, should be protected. This made necessary, except for the Yellowstone River, the gathering of more complete data than was available through previous State Board of Health studies concerning existing pollution and the cataloguing of environmental characteristics of the natural waters of the state. This information is necessary for the classification of natural waters on the basis of their most beneficial uses by the Water Pollution Council.

The Yellowstone River surveys, conducted in 1955 and 1956 by the Montana State Board of Health, the North Dakota Department of Health, and the United States Public Health Service, provided necessary data for its classification. This report contains basic survey information collected in 1957 in regard to the Columbia River drainage in Montana; additional information gathered in 1958 and subsequently will be reported later. Studies on the Missouri River drainage in Montana are underway and, upon completion, will be compiled as a basis for its classification.

The State Board of Health, under policies established by the Council, is responsible for the administration of the Water Pollution Act, with the Board being authorized to modify Council actions when necessary to protect human health. The stream survey program was undertaken by the Division of Environmental Sanitation to carry out this program.

At the request of the Chairman of the Council and others, a fishery biologist was assigned to the water pollution program by the Fish and Game Commission for the purpose of stream survey and classification. In addition, a stream survey team consisting of a biologist, a public health engineer, and a chemist has been employed by the State Board of Health during the summer to work with the regular water pollution staff.

The information contained in this report, plus other information gathered in 1958, has been used as a basis for the classification of the waters of the Columbia River Drainage in Montana. Hearings concerning this proposed classification were held during late summer, 1958, and final adoption of the proposed water uses resulting from these hearings was made by the Council during their December, 1958, meeting. The State Board of Health concurred with the classification at their January 17, 1959, meeting as finally adopted by the Council.

G.D. Carlyle Thompson

March 30, 1959

G. D. Carlyle Thompson, M.D.
Acting Executive Officer
Montana State Board of Health

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SUMMARY

1. In order to obtain basic information necessary for the classification of streams and the establishment of standards of water quality by the Montana Water Pollution Council, the State Board of Health conducted a physical, chemical, bacteriological, and biological survey of the Columbia River drainage in Western Montana.

2. This report covers the period from March to mid-November, 1957.

3. The study area is divided into three subsections for the purposes of discussion: (a) The Clark Fork (main stem and major tributaries except the Flathead), (b) The Flathead River and major tributaries, and (c) The Kootenai River.

4. Sampling stations were established above and below known sources of pollution, above and below entering streams, and in streams free of major pollution.

5. Standard methods of sampling and analysis were employed except that an additional technique of bottom sampling was developed and applied.

6. A literature survey was conducted on the application, importance, and recommended limits of each specific measurement or pollutant studied and is presented.

7. Chemical water analyses conducted include measurement of dissolved oxygen, pH, total alkalinity, hardness, chlorides, sulphates, and phosphates for the entire study area and determinations of iron, lead, zinc, copper and arsenic concentrations of the upper Clark Fork River.

8. Water temperature and turbidity results are included in the chemical portion of the report.

9. Analysis of MPN coliform organisms were made for the entire study area and collections of bottom fauna were taken at each sampling station.

10. Gross pollutional conditions exist in the Clark Fork River above Warm Springs, a section of stream which is unclassifiable by law, and with the construction of a large waste treatment pond near Warm Springs by the Anaconda Company, stream conditions below this point are rapidly improving.

11. Seventy five (±13.3) percent of the composition of bottom collections from clean-water stations in the Clark Fork Study Area was found to consist of organisms intolerant of pollution (stonefly, mayfly, caddiesfly, dragonfly and aquatic butterfly larvae).

12. Based on bottom fauna analysis, polluted water conditions exist in the Clark Fork River from Warm Springs to the Bitterroot River with evidence of conditions approaching gross pollution between Warm Springs and Deerlodge, between Deerlodge and the Little Blackfoot River, below Garrison, between Missoula and the Bitterroot River, and below Plains.

13. Other determinations (physical, chemical, and bacteriological) do not support the biological findings that the stream receives organic wastes from the communities of Garrison and Plains; however, further study of these sections is suggested in case the indications of pollution are not a result of sampling error.

14. Summer-season, recovery zones from the Butte-Anaconda and Missoula waste discharges are centered around Rock Creek and Superior respectively.

15. pH is not considered a limiting factor with regards to the various water uses throughout the classifiable study area.

16. Raw sewage discharge to the Clark Fork renders the stream unsafe (bacteriologically) for any use other than agricultural and industrial in a 12-mile section below Deerlodge, a 15-mile section below Drummond, a 40-mile section below Missoula and the river adjacent to Thompson Falls.

17. Only two short sections of the Clark Fork below the new Anaconda Company settling pond and above Warm Springs Creek, and below Paradise were found to be below the maximum permissible limits of MPN coliform organisms recommended for an unfiltered water supply.

18. Safe recreational use (excluding fishing) of the Clark Fork is restricted to the section between Warm Springs Creek and Deerlodge, near Rock Creek, and between St. Regis and Thompson Falls.

19. Bacterial analyses indicate that care should be exercised by anglers, hunters, and trappers when using the sections of the Clark Fork River between Deerlodge and Bearmouth, between Missoula and Alberton, and adjacent to Thompson Falls since the average MPN coliform organism content of these portions of stream exceed the limits established for Class D use of water.

20. The Clark Fork River between Warm Springs Creek and Deerlodge, Garrison and Flint Creek, Bearmouth and Missoula, Alberton and Thompson Falls Reservoir, and below Birdland Bridge to the Montana-Idaho Border is deemed safe for use as a Class B water source for municipal use. However, the extreme hardness of the section of stream above Flint Creek renders it undesirable for such use and the portion of river above Rock Creek exceeds or approaches the writer's recommended maximum limit of allowable sulfates for all uses other than as a source of municipal water supply.

21. Lower Warm Springs Creek is polluted and near-septic conditions were found below the discharge of raw sewage from the State Hospital. (The 1958 survey results indicate improvement in conditions at the latter station). Any use of the water from the section of stream adjacent to Warm Springs is hazardous from the standpoint of its disease producing potential.

22. Flint Creek from Philipsburg to its confluence with Lower Willow Creek is badly polluted by the discharge of untreated domestic sewage and mine-mill wastes. The highest MPN coliform organism content in the entire study area was recorded from this stream immediately downstream from Philipsburg.

23. The Bitterroot River was found to be in very good condition and suitable as a source of water for Classes B, C, D, and E use. An indication of some organic waste being discharged to the river near Stevensville was evident.

24. In many cases, the number of bottom samples collected from streams of the Flathead River Study Area is considered inadequate, however, other determinations (chemical and bacteriological) substantiate the conclusions drawn from biological results.

25. The Flathead River constitutes a relatively soft to moderately hard source of water for domestic use, however, sewage pollution from Whitefish via the Stillwater River, Ashley Creek, and Polson render the entire stream from Kalispell to its confluence with the Clark Fork, unsafe for use as a Class A water supply.

26. A short section of the Flathead adjacent to Kalispell and the river from its confluence with the Little Bitterroot to the Clark Fork is unsafe for any use except agricultural and industrial.

27. The Flathead River from Kalispell to about ten miles above Flathead Lake and from Polson to the Clark Fork is considered potentially dangerous from a bacterial standpoint for use by swimmers, anglers, hunters and trappers.

28. Bottom collections indicate an adverse effect on the Flathead River by the discharge of inadequately treated sewage from Kalispell via Ashley Creek and from Polson with recovery to normal stream conditions retarded by silt loading from agricultural practices particularly along the Little Bitterroot River.

29. Sewage discharge from Whitefish exerts an adverse effect upon the Whitefish River from the point of discharge to its confluence with the Stillwater River. The Whitefish River and Lake above town constitutes a very good water supply requiring only chlorination, however, the river below town is unsafe for any use except agricultural and industrial.

30. Near septic conditions of gross pollution exist in Ashley Creek below the discharge of inadequately-treated sewage from Kalispell and MPN coliform organism analyses indicate that the creek below this point is extremely unsafe for any use.

31. Bottom samples from Hot Springs on the Little Bitterroot River indicate a normal stream situation above Hot Springs with a detrimental effect on the river by organic wastes from the Community, however; MPN analyses at the two stations suggest that excretal wastes are discharged to the stream from a source above town.

32. Spring Creek, both above and below Ronan, exhibits polluted water conditions as shown by bacteriological and biological data with MPN results indicating that the use of the stream should be confined to agricultural and industrial.

33. Mission Creek apparently carries wastes (organic or inorganic) above town in addition to raw sewage from St. Ignatius as indicated by bottom samples. The coliform index to fecal pollution indicates that the stream below St. Ignatius should be restricted to Class E use while only the Class A use of the water above town should be excluded.

34. Bacteriological and biological results from the Kootenai River (main stem) are in conflict and this stream is recommended for more intensive study as are several streams of the Flathead Study Area.

35. The Kootenai River above its confluence with the Tobacco River is considered safe for all uses while the section between the Tobacco River and Libby should be restricted from Class A and C use. The river from Libby to the Montana-Idaho border is considered safe for Class E use only.

36. The Tobacco River above Eureka is not safe for Class A and C use and below Eureka, use should be restricted to agricultural and industrial.

RECOMMENDATIONS

1. More 24-hour dissolved oxygen, MPN, B.O.D., water termperature and chlorides analyses be conducted in critical sections of streams under investigation in order to lend more significance to "grab" samples.

2. Further investigation be conducted of (a) the Clark Fork River below Garrison and Plains, (b) the Little Bitterroot River above Hot Springs, (c) Spring Creek above Ronan, and (d) Mission Creek above St. Ignatius.

3. A more intensive and extensive survey be conducted of the Kootenai River and its major tributaries in Montana including the Yaak and Tobacco Rivers in view of the proposed pulp mill and water development outlined for the area.

4. Consideration be given of the placement of a properly equipped and experienced sanitary scientist at a permanent field station in the study area (possibly Missoula) to monitor changing stream conditions and to enable closer cooperation between municipalities, industries and stream pollution control authorities.

INTRODUCTION

With the recognition of recreation, fishing, agriculture and industry as legitimate users of natural waters and the passage of the Water Pollution Act of 1955 (Appendix A) by the 34th Legislative Assembly of Montana, it became necessary to learn more about the prevailing ecological conditions of the waters of Montana. The Water Pollution Act provides for the appointment of a State Water Pollution Council charged with, among other duties, the classification of water according to its most beneficial use and the adoption of a set of water quality standards (objectives). The State Board of Health is given the responsibility of administration of the Act under policy established by the Council. In order to classify the waters of the state and establish standards of water quality, an investigative program of the chemical, bacteriological and biological characteristics of the waters of the state was initiated by the Environmental Sanitation Division of the Board.

This report includes the results of a stream survey conducted on the Columbia River Drainage in Montana and contains information gathered from the Clark Fork and Kootenai Rivers and major tributaries. The study period covered extends from March to November, 1957.

The cooperation of the many land owners and industrial and municipal officials contacted by the survey crew, is greatly appreciated. The extra devotion to duty exhibited by the members of the survey team which consisted of Dr. Sheldon P. Hayes, Microbiologist of the Weber College, Ogden, Utah teaching staff, Mr. N. Bruce Haynes, Sanitary Engineer of the MSC engineering teaching staff, and Mr. Clarence Ryan, Chemist, is commendable. Gratitude is extended to the USPHS for providing technical advice and assistance through the services of Mr. John N. Wilson, Regional Biologist, stationed at Portland, Oregon. The cooperation of the Montana Fish and Game Department, consisting of active participation in the program and provision of services and facilities, is gratefully acknowledged.

GENERAL INFORMATION

This report is intended primarily for the use of the sanitary engineer and the administrator of the water pollution control and abatement program, however; the use of technical language is restricted to a minimum in order that others may gain a better understanding of the results obtained, the survey procedures involved, and the general effect of various pollutants upon the water uses involved.

DESCRIPTION OF THE STUDY AREA

The Clark Fork River and its tributaries, including the Flathead River, drains the west slope of the Continental Divide in Montana and part of southeastern British Columbia, Canada. The Kootenai River originates in Kootenay National Park, British Columbia, and flows along the west slope of the divide south into Montana, thence west into northeastern Idaho. Leaving Idaho it re-enters British Columbia and joins the Columbia at its exit from Kootenay Lake. Hence, the Flathead and the Kootenai Rivers cross the International border between Montana and British Columbia.

Much of the Clark Fork River drainage area from Butte to the Idaho border is of igneous origin, while the Flathead and the Kootenai River drainages are glaciated igneous and sedimentary deposits. The Flathead-Bitterroot Valley system forms the southern end of the Rocky Mountain Trench which extends from Montana about 900 miles northward into Alaska.

The streams of this area, with the exception of those in the Bitterroot and the Flathead, flow through canyons with steep, precipitous slopes. In most cases, flood plains are not evident. This general physiography of the area greatly aggravates the problem of access for the survey crew.

Five plant-life associations are represented: Grassland, Foothill, Montane, Sub-alpine, and Arctic:

Much of the Grassland zone on the valley floor is being cultivated for the production of irrigated grain crops, as is some of the Foothill zone. However, most of the Foothill zone, which is not well represented in the Kootenai and north Flathead areas, is grazing land.

Climax vegetation on the Foothill Association was **formerly** mixed short and intermediate grasses, juniper and mountain mahogany. Intensive grazing of this zone has affected a regression to short grasses representing the present day disclimax.

The Montane Association is represented by the climax tree, ponderosa or yellow pine in the lower altitudes and above this belt a douglas fir - western larch zone, north of Missoula and a douglas fir - lodge pole zone south of Missoula.

The Sub-alpine Association consists of Engleman Spruce and alpine fir and the Arctic Zone is represented by small, isolated areas of perpetual snow on the slopes of the mountain peaks.

Succession to climax vegetation is retarded in much of the Montane and Sub-alpine Association by forest fires.

The climate of western Montana is greatly influenced by the Pacific Ocean with annual precipitation approaching 24 inches per year in some areas, mostly in the form of snow.

The economy of the area is based on agriculture, foresty and mining. In addition, the natural beauty of the region draws an excellent tourist trade of which fishing and hunting form a great part. The stream bottoms consist mainly of sand, gravel, and rubble in the Clark Fork River drainage system to its confluence with the Flathead. The upper Flathead River and its tributaries are mostly gravel and rubble above Flathead Lake. This river in its lower reaches and the lower Clark Fork have a sandy bottom from above Dixon to Thompson Falls, Montana. The Kootenai River is the largest river in Montana and the stream bottom varies from sand in the areas of low gradient to boulders in the rapids areas.

The nature of the bottom materials of the Clark Fork from Butte to near Missoula reflects the past practice of mine and mill waste discharge to the river. Fine silt and precipitated chemical wastes are evident on the stream bottom and banks to a gradually decreasing degree from Butte to the Montana Power Dam at Milltown. With the construction of the new waste stabilization pond near Warm Springs, this sediment load has been greatly decreased and can be expected to be less evident as waste treatment facilities are improved.

EXPERIMENTAL DESIGN

The experimental design of the survey was reviewed in part with John N. Wilson, Regional Aquatic Biologist, U. S. Public Health Service, Portland, Oregon when he accompanied the project personnel on the initial survey of the portion of the study area in the vicinity of Missoula, Montana. The study area, with locations of stations and communities along the streams sampled is pictured in Figure 1.

The common names of stations, their locations and their corresponding U.S.G.S. river mileage indices are given in Appendix B, and hereafter for reasons of simplicity, stations shall be referred to by their mileage index and/or abbreviated common name.

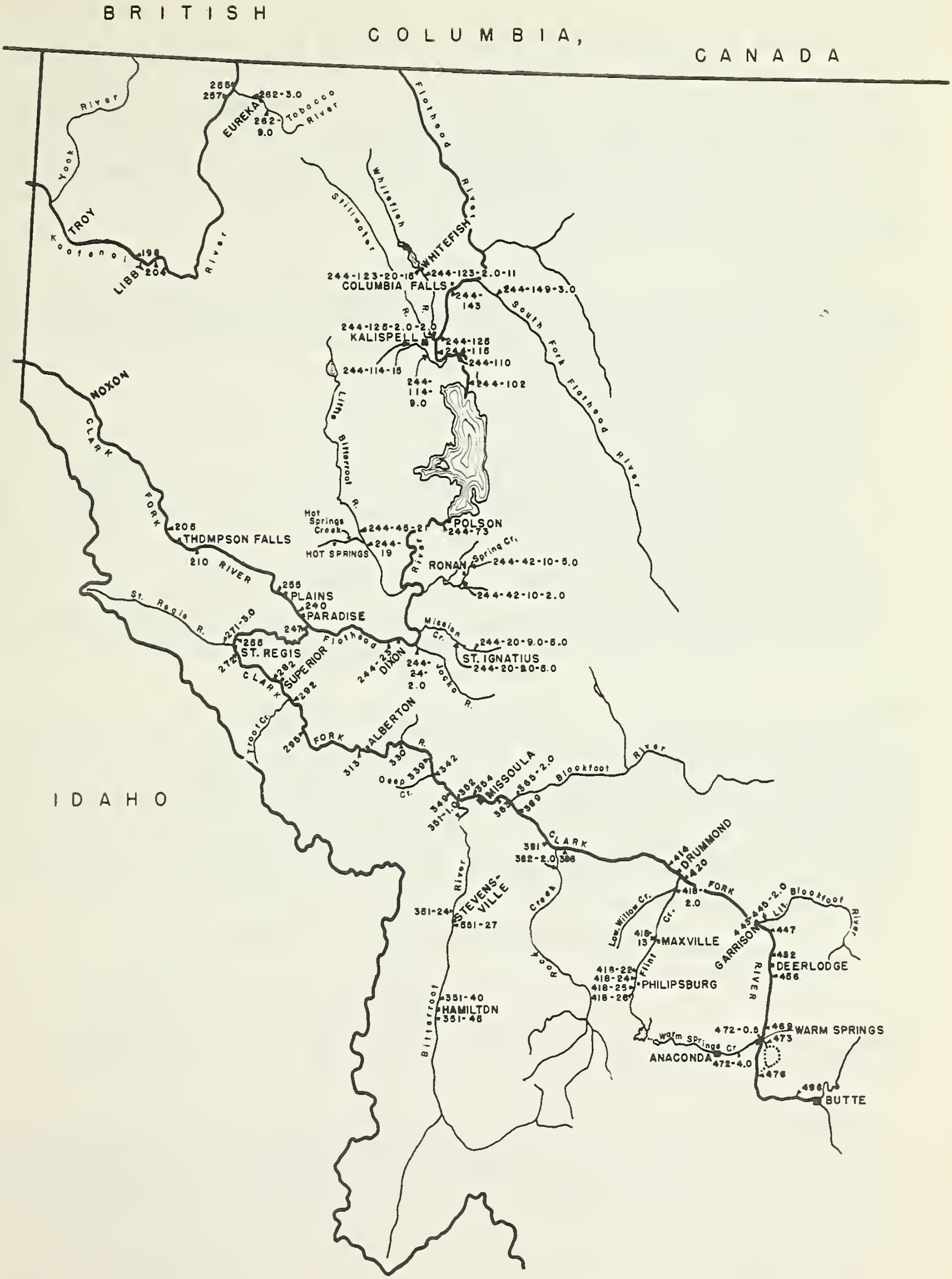


Figure 1. Pacific slope streams of Western Montana. showing location of collection stations sampled during 1957.

Portions of the study area were traversed entirely by powered boat as follows: The section of the Clark Fork River extending from Station 363 (near E. Missoula) to 342 (Deep Creek 15 miles below Missoula) accompanied by Mr. Wilson during March 1957 and the section from 342 (Deep Creek) to 330 (Six Mile) during all sampling periods conducted by the permanent project personnel. Mr. Wilson and Mr. William Fixsen, Engineer, of the Denver office of the U. S. Public Health Service also accompanied the project biologist during the August 1957 survey.

A portion of the study area extending from Station 369 (above Milltown) to Station 295 (about 10 miles upstream from Superior) is being studied with the use of more intensive methods of sampling and analysis and will be reported on separately. This area is known as the Missoula-Pulp Mill Study Area of the Clark Fork River.

In general, sampling stations were located as follows:

1. Above and below known sources of pollution being discharged into the stream, with the "below pollution" station being located far enough downstream from the effluent to insure thorough mixing with the receiving stream.

2. Above and below the mouth of an entering stream.

3. At various locations in streams known to be free of municipal and industrial pollution. (Except agricultural, i.e., siltation from irrigation, overgrazing and cultivation).

A literature survey was conducted on the effect upon the water use, the application to water pollution control and abatement, and limits established by various agencies and states for each of the measurements made. Chemical analyses are presented first with bacteriological findings and biological results following in that order. In the discussion following biological procedures, an attempt is made to integrate all the information obtained in order to lend the most significance possible to the conclusions drawn.

CHEMICAL PROCEDURES AND RESULTS

Chemical water analyses, both those conducted in the field and those made in the State Board of Health Chemistry Laboratory in Helena, were performed as outlined in "Standard Methods for the Examination of Water, Sewage, and Industrial Wastes."

Analyses conducted in the field at the time of sampling included, determination of (1) dissolved oxygen by the Alsterberg (Azide) modification of the Winkler method, (2) pH by a colormetric method, (3) total alkalinity by the phenolphthalein-methol orange indicator method, (4) hardness by the EDTA titration (Versenate) method, and (5) chlorides by the Mohr method (Appendix C).

Water samples were taken at selected stations and forwarded to the Laboratory for analysis of (6) sulphates, (7) phosphates, and (8) iron, lead, zinc, copper and arsenic (Appendix D).

Water temperatures (9) were determined with a Taylor pocket thermometer calibrated in Fahrenheit and turbidity (10) was measured with an U. S. Geologic Survey model turbidity tape (Appendix C).

(1) Dissolved Oxygen: The concentration of dissolved oxygen is one of the most important indices of the purity of a stream. One of the first indications of the presence of organic pollution, is a decrease of the dissolved oxygen content of the water somewhere below the source of pollution. Since the deoxygenation of water is a comparatively slow process, the point of lowest dissolved oxygen content may be several miles downstream from the point of pollution.

The quantity of oxygen dissolved in fresh water from the atmosphere is dependent upon the temperature and the barometric pressure. The solubility of oxygen decreases with a rise in water temperature and altitude (or inversely, a fall in barometric pressure). Since altitudes of the sampling stations established in the study area vary from less than 2,000 feet in the Kootenai Drainage to more than 5,000 in the Clark Fork Drainage, correction factors, as presented by Welch (1948) were used to obtain the theoretical amount of the gas which would be present at sea level or at a barometric pressure of 760 millimeters of mercury. These values were then used to obtain the saturation value of dissolved oxygen based upon the water temperature at the time of sampling. It is recognized that this procedure induces some error since barometric pressure varies with weather conditions at any given altitude, however, it is felt that the error is small. Such error could be eliminated by recording barometric pressure at the time of sampling; however, a barometer meeting these requirements of portability and sensitivity is unavailable.

It will be noted that many dissolved oxygen saturation values presented in Appendix C exceed 100 percent. This phenomenon is a result of active photosynthesis by plants, particularly algae. A by-product of the synthesis of carbon dioxide and water to glucose is, of course, oxygen. Air contains only 20.9 percent oxygen, the rest being mainly nitrogen. When air is dissolved in water, the amounts of oxygen and nitrogen dissolved depend upon the partial pressure and solubility of each gas (oxygen is about twice as soluble in water as nitrogen). At most normal, summer, stream temperatures, the solubility of pure oxygen is nearly five times that of air; therefore, water has the ability to absorb more oxygen than the amount available from the atmosphere. When additional oxygen is supplied by photosynthesis, dissolved oxygen saturation values can easily exceed 100 percent during seasonal and diurnal peaks of photosynthetic activity.

The dissolved oxygen content of a stream varies considerably during the year and during the day. Saturation values are highest during summer and during the daylight hours, since photosynthesis is highest during this period of time. Since all survey work was normally conducted during the regular eight-hour work day, a twenty-four hour dissolved oxygen analysis series was conducted at three stations located below Missoula (stations 342, 348 and near 330) in order to gather information which would lend more significance to "grab" samples taken at various times during the work day (Table 1). Dissolved oxygen analyses were conducted at two hour intervals at each station commencing at 10 A.M. (1000) August 2 and ending at 8 A.M. (0800) August 3. The results at each station were corrected for altitude, converted to saturation values at temperature, averaged, (Table 1) and plotted (Figure 2) to demonstrate the effect of photosynthesis and respiration upon the dissolved oxygen content of the Clark Fork River twelve to twenty miles below Missoula.

Table 1. A 24-hour dissolved oxygen analysis series from three stations on the Clark Fork River 12 to 20 miles downstream from Missoula, Montana, August 1-2, 1957.

		Temperature (F°)			D.O., ppm			% sat., D. O.[1]			Ave.[1]	Ave.[2]
Date	Time	Deep Cr.	Mar. R.	6-mi.	Deep Cr.	Mar. R.	6-Mi.	Deep Cr.	Mar. R.	6-mi.	% sat.	D.O. ppm
8/1	1000	63.0	63.5	65.0	8.0	8.0	8.1	92	93	95	93.3	8.0
"	1200	65.5	54.5	65.0	8.6	8.3	8.3	102	97	97	98.7	8.4
"	1400	67.0	66.0	66.0	8.6	8.6	8.6	103	102	102	102.3	8.6
"	1600	69.0	67.0	66.0	8.1	8.4	8.4	98	100	99	99.0	8.3
"	1800	68.5	67.0	67.0	8.1	8.1	8.1	98	97	97	97.3	8.1
"	2000	66.5	67.0	67.0	8.1	8.1	8.1	97	97	97	97.0	8.1
"	2200	66.0	66.0	66.0	7.8	7.8	7.8	87	87	87	87.0	7.8
"	2400	64.0	65.0	66.0	7.2	7.5	7.4	83	88	87	86.0	7.4
8/2	0200	63.0	64.0	64.0	6.8	7.2	6.9	78	83	80	80.3	7.0
"	0400	62.0	63.0	62.0	6.9	6.6	7.4	73	74	83	76.7	7.0
"	0600	61.0	61.0	61.5	6.9	6.8	7.2	77	72	80	76.3	7.0
"	0800	61.0	61.0	62.0	7.5	6.9	7.2	83	77	80	80.0	7.2
Average		64.7	64.6	64.8	7.7	7.7	7.8	90[3]	90[3]	91[3]	89.5[4]	7.7[4]

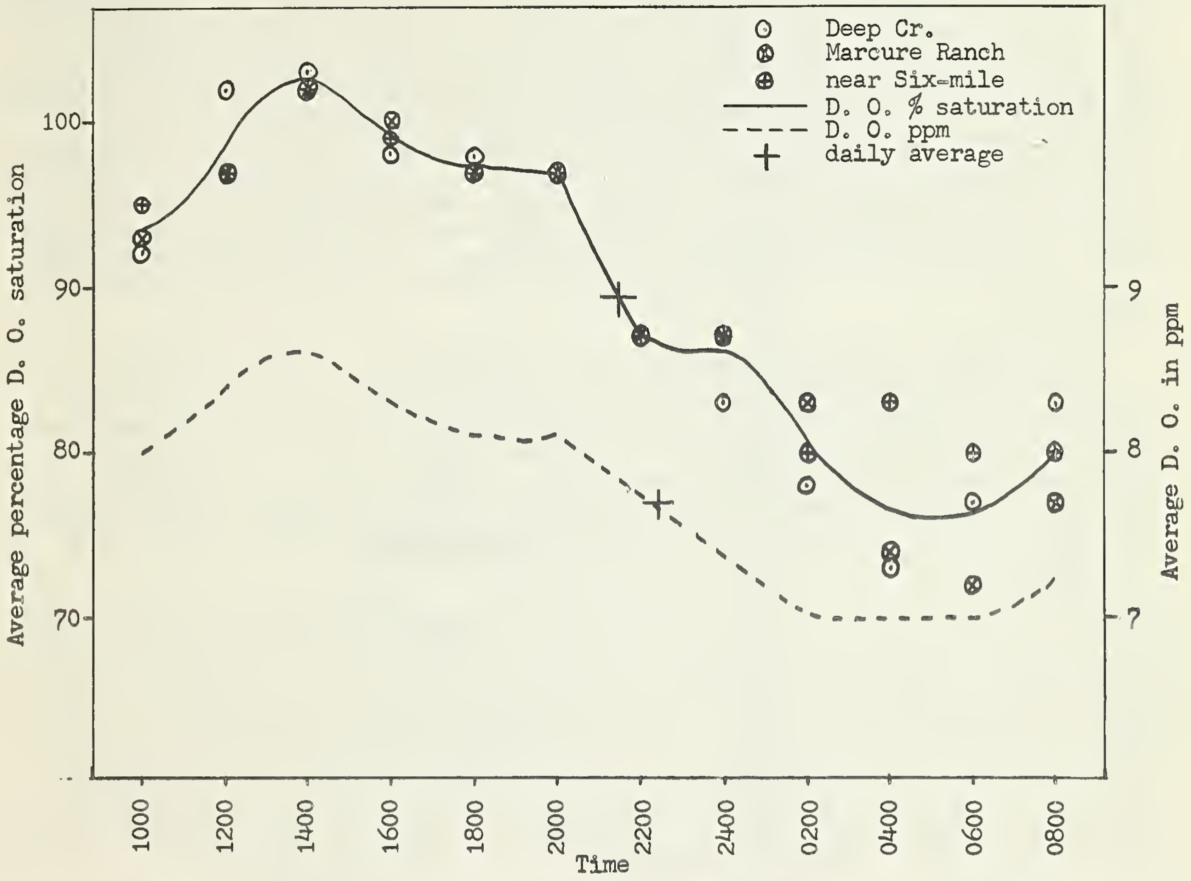
[1] corrected for altitude and temperature
[2] actual dissolved oxygen values in ppm not corrected for altitude
[3] based on average daily temperature and dissolved oxygen
[4] Average of all values taken at all stations

The significant points of Figure 2 are as follows: 1. The maximum percentage saturation of dissolved oxygen occured at 2 P.M. (1400) indicating that photosynthesis is at a peak at this time. 2. The minimum percentage saturation of dissolved oxygen occured between 4 and 6 A.M.(0400-0600) before photosynthesis recommenced and after a period of about 10 hours of plant and animal respiration in the absence of oxygen production by plants. 3. A sharp and rapid decrease in dissolved oxygen saturation occured at sunset.

An additional factor is worthy of mention: The dissolved oxygen saturation values presented here are, in general, lower than those computed for other sections of the study area for this time of the year (Appendix C). This is a reflection of retarded biological activity induced by toxic materials being discharged to the river with the municipal and trade wastes from the Missoula area.

Further analysis of Figure 2 and Appendix C indicates that, at least for these data at this time of the year, a "grab" sample for the dissolved oxygen analysis should be taken around 10 P.M. and/or 9 A.M., if such a sample were to represent the average dissolved oxygen content and average percent saturation of dissolved oxygen over a 24-hour period. However, the average dissolved oxygen value is not necessarily a desirable criterion from which to judge the true oxygen cycle of a stream and the author believes that the minimum dissolved oxygen content is more useful. Dissolved oxygen saturation values need only to drop below the minimum toleration limits for aquatic life, such as game fish, for a few minutes and the sport fish population of a body of water will be lost or drastically reduced. For

Figure 2. Dissolved oxygen trend during a 24-hour period determined from results at three sampling stations on the Clark Fork River near Missoula, Montana, Aug. 1-2, 1957.



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these data, analyses should be conducted around 0500 to determine the minimum concentration of dissolved oxygen present during a 24-hour period.

When the percentage saturation of dissolved oxygen falls below 57 percent in a fishing stream, game fish are generally adversely affected (Ellis, et al, 1946). A desirable oxygen value for game fish is at least 75 percent of saturation since many "rough" fish, such as carp, can live in water with a dissolved oxygen content as low as 30% of saturation (Klein, 1957). The concentration of dissolved oxygen is of particular importance to fish when toxic substances are discharged to a stream since the effect of poisonous materials on fish is increased when the concentration of dissolved oxygen is low (Hubbs, 1933 and Ellis, 1947). Consequently, sublethal amounts of toxic substances can prove relatively innocuous during the day, but lethal at night when the dissolved oxygen concentration decreases (Klein, 1957).

Much literature is available concerning the minimum dissolved oxygen concentration necessary to sustain healthy aquatic life, especially fish, and the concentration below which fish will be killed by short time exposures. Oxygen requirements of fish vary with the species and age of the fish, with prior acclimatization, with temperature, with the concentration, with other substances in the water and with several other factors. Temperature affects not only the amount of dissolved oxygen available, but also the rate at which fish utilize such oxygen. For example, the California Water Pollution Control Board (1952, revised 1957) cites a report by one investigater (probably Southgate, 1948), that gold fish consume 16 milliliters of oxygen per kilogram of body weight at 43° Fahrenheit: 50 milliliters at 50°; and 90 milliliters per kilogram at 70° degrees, and that the asphyxiation values for trout are about 1.16 ppm dissolved oxygen at 50° Fahrenheit and 2.14 ppm at 64.5° degrees for short exposure periods. For longer exposures, the asphyxial points would probably be much higher; however, it has also been demonstrated that fish may become acclimatized to low oxygen concentrations if such changes are arrived at over an extended period of time with corresponding gradual decreases in temperature.

Ellis (1937 and 1946) believes that under average stream conditions, 3.0 ppm or less of dissolved oxygen should be regarded as lethal, and that to maintain a varied fish fauna in good condition, the dissolved oxygen concentration should remain at 5.0 ppm or higher. For trout in soft water, the lower limit has been set as high as 6.0 ppm. In view of this information, the Water Pollution Council of Montana has established 5.0 ppm as the minimum allowable dissolved oxygen concentration for water used for the growth and propagation of fish and other aquatic life (Appendix E).

Before concluding this introduction of the complicated role of dissolved oxygen in water pollution control, it must be mentioned that supersaturation of water with dissolved oxygen has also been reported as detrimental to fish. One investigation (A.W.W.A. 1938) reports death of fish when dissolved oxygen reached 300 percent of saturation, the lethality being attributed to oxygen bubbles surrounding the gills. A case of die-off similar to this is known to have occurred in a farm pond in eastern Montana. (For a more thorough discussion of the role of dissolved oxygen in stream ecology, the reader is referred to a 1958 publication of the Robert A. Taft, Sanitary Engineer Center, entitled "O_2 Relationships in Streams").

With regards the effect of dissolved oxygen upon the use of water, the presence of the gas in municipal water supplies is considered desirable since it has no adverse physiological affect and increases the palatability of water. It may be detrimental by the corrosion of metal pipes and for many industrial uses of water, zero dissolved oxygen would be desirable as a means of inhibiting corrosion, especially in cooling waters (Pomeroy, 1951). For boiler feed water, the limiting dissolved oxygen concentrations have been given as 2 ppm for boiler pressures of 0 to 150 pounds per square inch; 0.2 ppm for 150 to 250; and 0.0 ppm for 250 psi and up (A.W.W.A., 1950).

Results of Dissolved Oxygen Analysis: With regards this study and the application of dissolved oxygen anaylses, only three stations were found where dissolved oxygen values were below the minimum required to render the water suitable for the various uses recognized by the Water Pollution Council and the State Board of Health (Appendix C, Figures 3, 4, and 5).

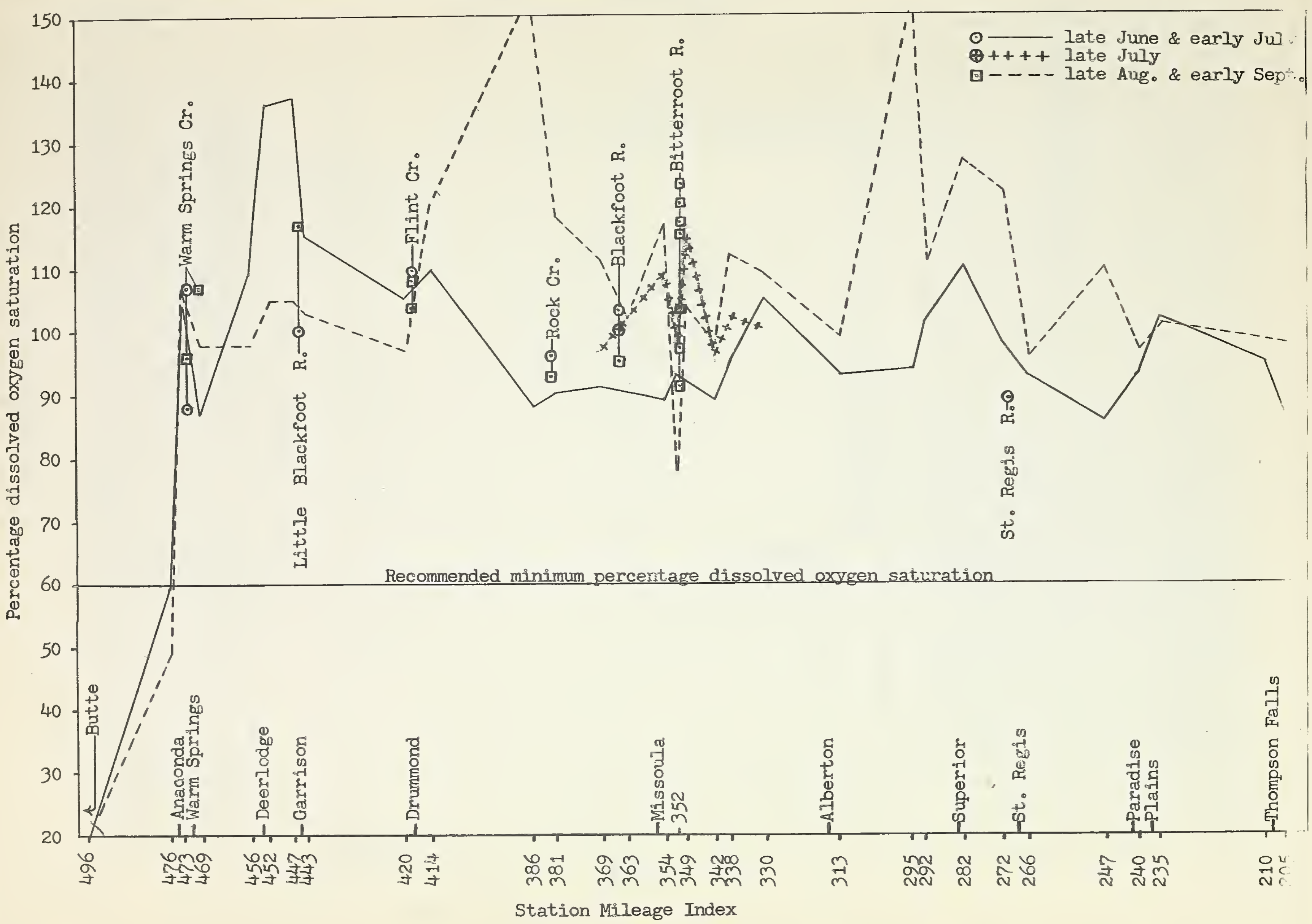
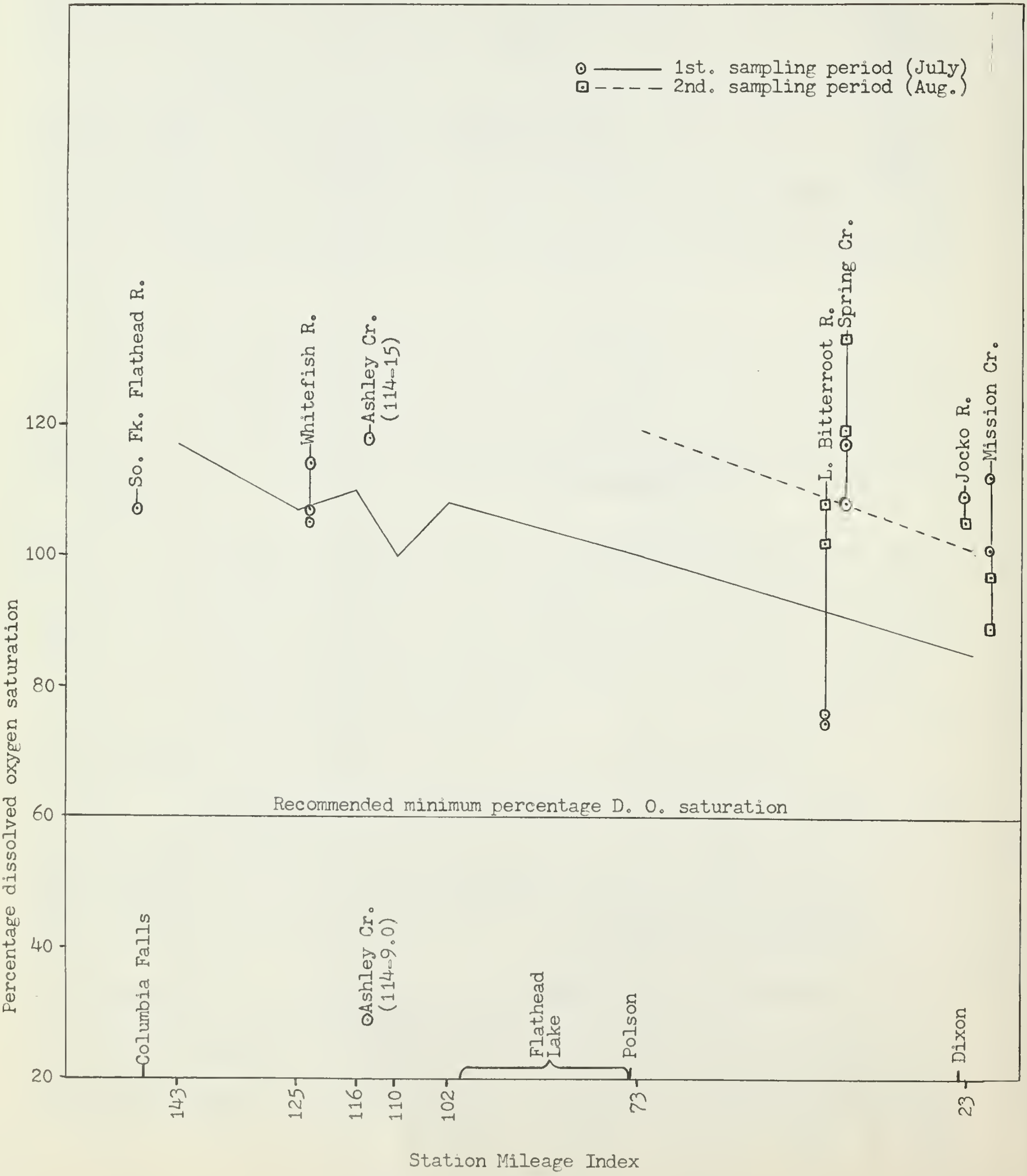


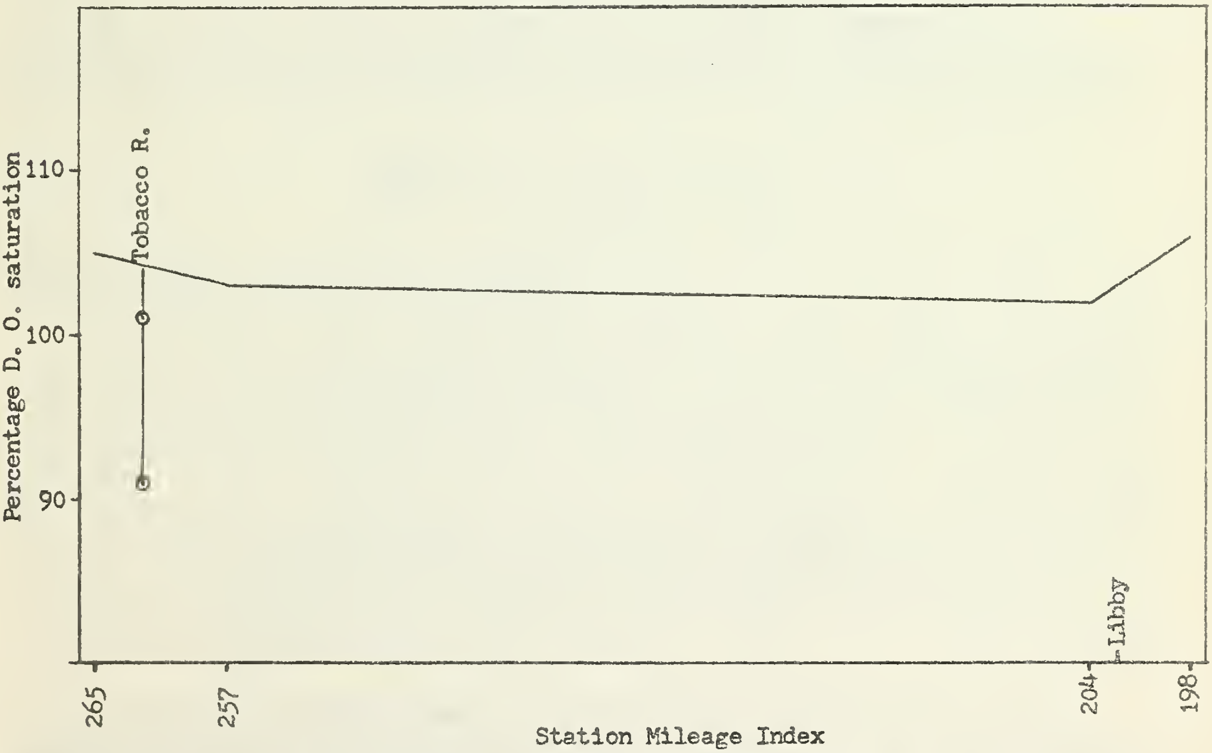
Figure 3. Dissolved oxygen percentage saturation values determined from D. O. concentrations obtained from sampling stations in the Clark Fork Study Area, 1957.

Figure 4. Percentage dissolved oxygen saturation values computed from D. O. concentrations in the Flathead Study Area, 1957.



Two stations (496 and 476) are located on the Clark Fork River above Warm Springs in the section of stream which is classified for industrial use only (Appendix C, Figure 3). (Attention is called to the much higher level of percentage dissolved oxygen saturation during the late July, August, and early September periods resulting from maximum seasonal photosynthesis, Figures 3 and 4. The other stream on which the dissolved oxygen content was found to be very low, was Ashley Creek below the discharge of the apparently inadequately treated municipal wastes from Kalispell, (Station 244-114-9.0, Figure 4). Ashley Creek was flowing 4.34 second feet on July 23, 1957, and is not capable of assimulating the heavy load of organic wastes discharged to it. It is believed that this is the only stream studied in western Montana in which a truly septic condition exists, with the possible exception of the Clark Fork above Warm Springs (Figures 3, 4 and 5). Oxygen "sag" in most of the other polluted streams of the study area is "masked" by dilution of clean water entering from tributaries.

Figure 5. Percentage saturation values computed from dissolved oxygen determinations from the Kootenai Study Area, 1957.



(2) Hydrogen Ion Concentration: The symbol "pH" is used to designate the logarithm (base 10) of the reciprocal of the hydrogen ion concentration, thus, if $(H +) = 10^{-5}$ mols per liter, then, pH = 5. The pH scale affords a convenient method of expressing the intensity of the alkalinity or acidity of a water. On the other hand, pH gives no indication of the quanity of alkali or acid present (Klein, 1957). This is determined by titration with standard acid or alklai respectively (A.P.H.A., and A.W.W.A., and Federal Sewage and Industrial Wastes Association, 1955).

Not only is the hydrogen ion a potential pollutant in itself; it also controls the degree of dissociation of many other substances and, since, the undissociated compounds are frequently more toxic than the ionic forms, pH may often be a highly significant factor in determining threshold concentrations of other waste materials discharged to natural waters (Doudoroff and Katz, 1950).

The concentration of weakly dissociated acids (such as carbonic acid) and bases markedly affects the pH value and the ease with which it can be altered. For this reason, pH should not be confused with acidity and alkalinity. The presence of carbonates, phosphates, borates and similar ions gives water a "buffering" power so that the addition of an acid or a base has less noticeable affect upon the pH. The best waters for many uses are those with pH values between 7 and 8 and having a methol orange alkalinity of 100 ppm (expressed as calcium carbonate) which helps to prevent any sudden change in pH (Huet, 1941). For example, waters with an alkalinity of less than 25 ppm are not considered good fish habitat since, owing to their low "buffering" action, death of, or avoidance by fish may occur when a sudden fall in pH is brought about by an acid discharge or by organic acids from decaying vegetation.

As with dissolved oxygen, photosynthesis by plants can also lead to rather high pH values in streams by the utilization of the half-bound carbon dioxide and conversion of the bicarbonate to the more alkaline carbonate (Klein, 1957):

$$2\ (HCO_3)^{-} \rightarrow CO_3^{=} + H_2O + CO_2\overset{\text{plants}}{\uparrow}$$

The pH of a raw water used for domestic and industrial purpose affects the taste, corrosiveness, chlorination, treatment, and industrial application of the water. Water acquires a sour taste at a pH of 3.9 or lower (Rohlich and Sarles, 1947) and corrosivity increases with the lower pH values (Langelier, 1946). The disinfecting action of chlorine diminishes with an increase in pH (Butterfield, et al, 1943) and the optium dosage of coagulating chemicals is influenced by pH as well as the "buffering" action of water (Von Gonzenbach, 1936 and Davis, 1942). Water suitable for most industrial uses should have a pH range of 6.5 to 8.0 (California State WPC, 1957) and the optimum pH for irrigation water depends upon the type of crop to be grown and the soil chemistry; in general, low pH values are desirable with alkaline soils and inversely, high pH with acidic soils. Of U. S. waters that support a good fish fauna, only 5 percent have a pH of less than 6.7, 50 percent have a pH of less than 7.6, and 95 percent have a pH less than 8.3 (Ellis, 1937).

As mentioned before the pH value determines the degree of dissociation of weak acids and bases, some of which may be more toxic in the molecular than the ionic form. For example, Jones (1948) showed that the toxicity of sodium sulfide to trout tends to increase as the pH is lowered from 9 to 6, that is, as the sulphide and the HS^- are converted to H_2S. Further, the hydrogen ion sometimes determines the toxicity of other substances in the water. For example, fish that can tolerate pH values as low as 4.8 will die at pH 5.5 if iron in concentrations of 0.9 ppm is added to the water (Brandt, 1946 and Minkina, 1946).

The Water Pollution Control Council, upon the advice of the Board of Health staff, has adopted a pH range of 6.5 to 8.5 for classes A. B, C, and D waters, that is, waters used as a source for domestic supplies, recreation, and fish and game. Water with a pH range of 6.0 to 9.5 is considered to be suitable for agricultural and industrial use (Appendix E.).

Results of Hydrogen Ion Determination: Hydrogen ion concentration of the Clark Fork River and its major tributaries (except the Flathead River) was measured during two sampling periods for 1957; the last of June and the first part of July and the latter part of August and early September; in addition, the section of river near Missoula (Station 369 and 330) was sampled during late July (Appendix C, Figure 6). On the basis of the Water Pollution Council Stream criteria, the stream above the Anaconda Company settling ponds at Warm Springs is unsuitable for any use other than industrial waste disposal. During late summer, the pH was found to exceed the upper limits of 8.0 established by the Council for Classes A, B, C, and D water in a 37-mile section of the river between Drummond and Rock Creek and a 23-mile portion near Superior (Figure 6). These sections of river are undoubtedly the recovery zones corresponding with the discharge of the Butte-Anaconda and Missoula municipal wastes and the high pH values recorded here are a result of a high rate of photosynthesis due to the fertilizing effect of the sewage. It will be noted that the line graph described by pH determinations conducted during the latter part of August and early September, very nearly forms a "mirror image" of the line graph described by pH analyses conducted during late June and early July. Literature review of pH, acidity, and alkalinity leads to the speculation that the decomposition of the periphyton deposited in these highly productive sections of river during the prior summer, acts to reduce the pH by the production of acid-forming substances such as hydrogen sulphide and carbon dioxide. This phenomenon certainly should be subjected to more intensive investigation.

With regards hydrogen ion concentrations of the main stem of the Clark Fork and its major tributaries excluding the Flathead, this chemical measurement, per se, would not limit the use of these waters as agricultural or industrial water supplies, except that section of the river proper above Warm Springs which is exempt by law from classification.

Hydrogen ion determinations of the Flathead River study area indicate that the stream is suitable with regards pH for all uses, with the exception of one station on Spring Creek above the point of discharge of raw sewage from the community of Ronan which is considered low in hydrogen ion concentration from the standpoint of the streams' use as a source of drinking and culinary water (Figure 7).

Hydrogen ion concentration at the six stations established in the Kootenai drainage study area was found to fall well within the limits prescribed by the water pollution council for all water uses (Appendix C).

(3) Alkalinity: As mentioned under pH above, alkalinity of a water is a measurement of the quantity of alkali in solution (Klein, 1957). It is related to pH but high alkalinities should not be confused with high pH values. For example, a relatively pure water with a pH value of 7.0 will have a low total alkalinity, whereas a buffered water with a pH of 6.0 will have a high total alkalinity. (California Water Pollution Control Board, 1952, Revised 1957). Generally, alkalinity in natural waters is caused by the presence of bicarbonates, carbonates, and hydroxides (Standard Methods). Alkalinity is not a specific polluting substance, but, rather, a result of the effect of dissolved materials and environmental conditions.

Figure 6. Hydrogen ion concentration (pH) of the Clark Fork Study Area, 1957.

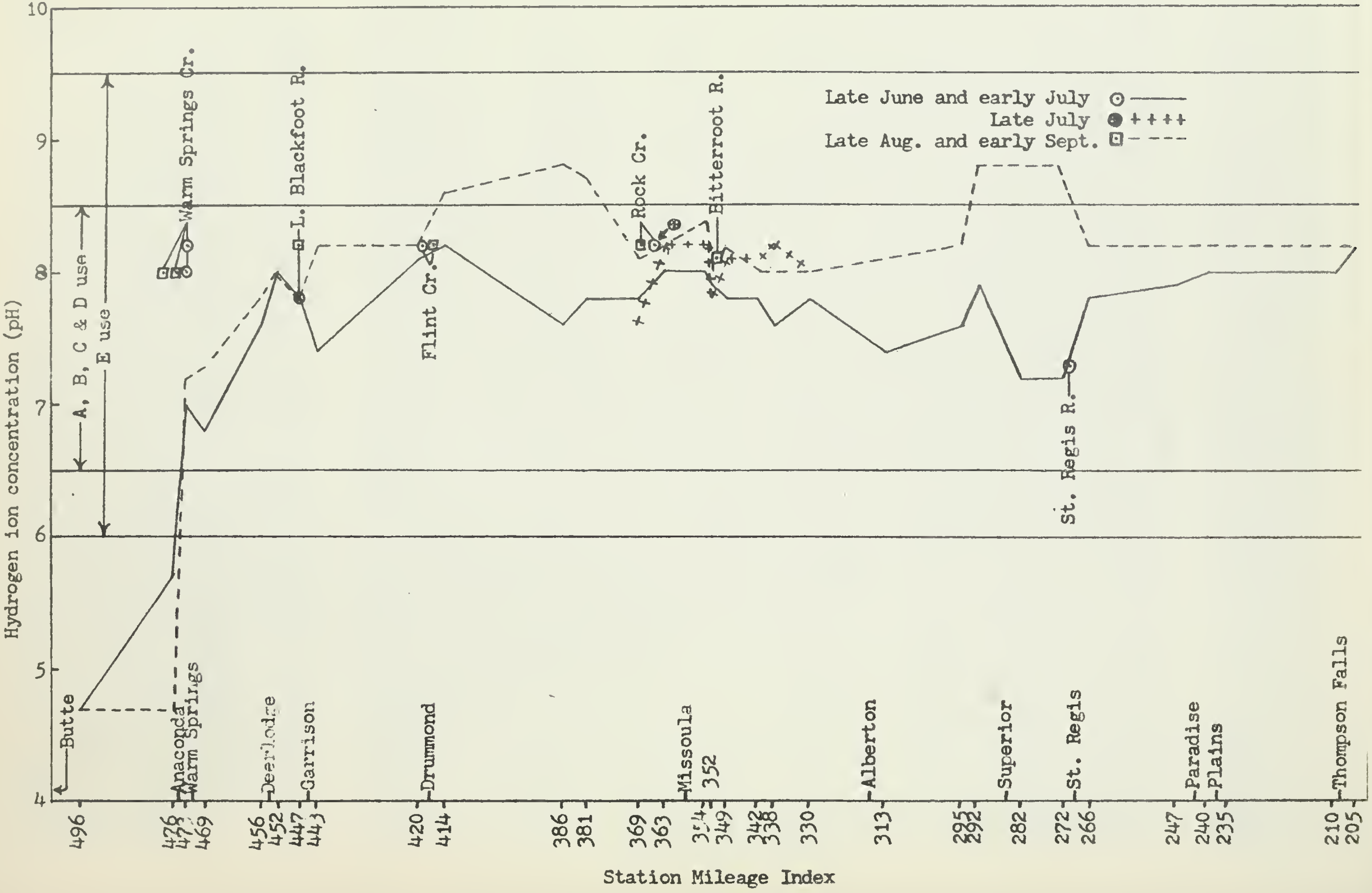
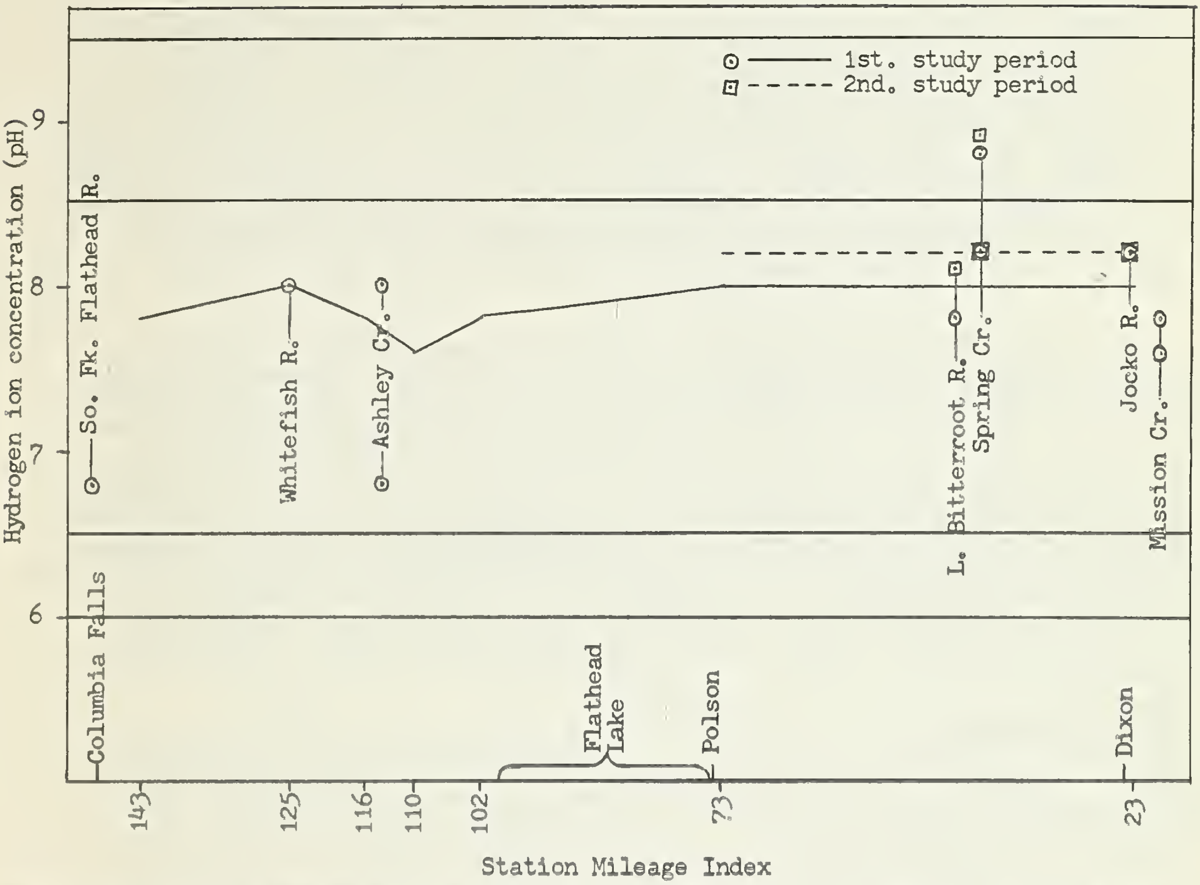


Figure 7. pH of the streams studied in the Flathead River Study Area, 1957.



Alkalinity, per se, is not considered detrimental to humans, but it is generally associated with high pH values, hardness, and excessive dissolved solids, all of which may be deleterious. Alkalinity is detrimental in food, ice and beverage processing, since it neutralizes natural taste-producing substances and increases the susceptibility of many acid-fruit beverages to bacterial action. In contrast, alkalinity is desirable in many industrial waters, especially if it serves to inhibit corrosion. Excessive alkalinity has an adverse effect on irrigation waters since it adds to the total salinity and it has been reported to be detrimental to domestic fowl and livestock. Carbonate alkalinity at a concentration of 50 ppm and greater, has been reported as producing diarrhea in chickens and, at concentrations of 170 ppm total alkalinity, may cause diarrhea in livestock. (California Pollution Control Board, 1952, Revised 1957). When produced almost entirely by bicarbonates, alkalinity does not appear to have a harmful affect upon aquatic life. Quantities of hydroxides, sufficient enough to raise the pH of natural waters above 9.0, have been shown to be lethal to fish. (Doudoroff and Katz, 1950). On the other hand, high alkalinity is antagonistic toward the toxicity of copper sulphate to brown trout fry (Warrick, et al, 1949).

U. S. Public Health Service Standards are followed where criteria have not been established by the Water Pollution Control Council or the State Board of Health.

Results of Alkalinity Determinations: On the basis of the Public Health Service Drinking Water Standards of 1946 (USPHS, 1946), alkalinity of the waters studied would not restrict its use for drinking and culinary purposes (Appendix C). Many industrial uses, such as food and fruit-juice processing, would be adversely affected particularly if such industries were to utilize water from the Clark Fork River above its confluence with the Flathead River. Alkalinity is not considered detrimental to irrigation and aquatic life in any of the waters of the study area. It will be noted that alkalinity is highest in the upper Clark Fork River below the Anaconda Company settling ponds at Warm Springs and gradually decreases downstream, probably as a result of the conversion of bicarbonates to the less soluble carbonates and from dilution by the less alkaline tributary streams. Alkalinity was not conducted at certain stations since interfering ions in samples from stations on the Clark Fork River above Deer Lodge inhibited titration (Appendix C).

In view of the potentially toxic substances discharged to the Clark Fork River from the Butte-Anaconda area, the high alkalinity existing in the upper portion of this stream is considered desirable. The antagonistic effect of carbonates and bicarbonates toward the heavy metal ions, particularly those of copper, iron, and zinc, reduces the deleterious action of these substances on the stream biota. This allows the natural purification potential of the stream to develop in a relatively short time of flow. With the construction and operation of the waste stabilization pond near Warm Springs and a coordinated program of waste treatment by the Anaconda Company Smelter at Anaconda during the summer of 1957, an immediate movement of game fish (brown trout) into the section of river adjacent to Deer Lodge was recorded. (Montana Fish and Game Department Creel Census information, unpublished).

(4) Hardness: The "hardness" of water is due mainly to the presence of calcium and magnesium, however, any substance which forms an insoluble "curd" or "scum" with soap, will cause hardness (California Water Pollution Control Board, 1952, Revised 1957). This property of soap has been used as an accepted test for hardness. Recently, the "Versenate" test has been perfected and is coming into general use in place of the more cumbersome soap test. As with alkalinity, hardness is expressed in terms of calcium carbonate equivalents.

The detrimental effects of hardness include excessive soap consumption in homes and laundries, the formation of scums and curds, the toughening of vegetables cooked in hard water, and the formation of scales in boilers, hot-water heaters, pipes and cooking utensils.

According to several writers (Thresh and Beale, 1925; Banks, 1936; Schacht, 1941; Ockerse, 1944; Chilean Nitrate Educational Bureau Inc., 1948; and Hasler and Wisby, 1950) hard waters have had no demonstrable harmful affects upon the health of consumers. The following summarization of literature concerning hardness was made by the California Water Pollution Control Board (1952, Revised 1957) with regards domestic water supplies:

> "Hardness over 100 parts per million becomes increasingly inconvenient, for it results in a waste of soap and the encrusation of utensils, (Phelps, 1948). In a few hard-water areas, a commonly prescribed limiting hardness is 140 parts per million (Taylor, 1949). In good water, the total hardness is usually below 250 parts per million (from Kl.Mitt. Ver. Wasser, Boden-,

> and Lufthyg, 1942, by A.W.W.A., 1946). The hardness of waters of "good" quality should not exceed 270 parts per million (Berger, 1942). In France, hardness in excess of 300 parts per million is considered suspicious and possibly indicative of pollution (Thresh and Beale, 1925). In England, it is believed that water with a hardness in excess of 315 parts per million should be softened, primarily to remove harmful magnesium salts; but the use of water with 315 parts per million hardness without preliminary softening has been sanctioned by the government. Hardness above 500 parts per million is considered unsuitable for general domestic purposes (Thresh and Beale, 1925; Taylor, 1949). In Germany, natural carbonate hardness above 350 parts per million is seldom found and water with hardness above 448 parts per million is considered to be polluted (Luning and Heinsen, 1934)."

The Montana State Board of Health has, since the early 1920's, used the U. S. Geological standards of water hardness classification to determine the advisability of using domestic water supplies as boiler water. The following table describes these standards:

Table 2. Classification of Waters According to Hardness

Hardness expressed as ppm $CaCO_3$	Description of water	Effect on boilers and Treatment Requirements
0 - 90	Relatively soft	Unlikely to form scale, no treatment necessary.
90 - 200	Moderately hard	Scale forming; can be used without treatment but boilers should be cleaned regularly.
200 - 430	Hard	Scale forming; softening necessary before use.
430 - 680	Very hard	Excessive scale formation; treatment imperative.
over 680	Excessively hard	Useless in raw state, even softening causes foaming.

Other industrial uses require waters ranging from very soft (0 - 50 parts per million) laundry water to allowable concentrations of hardness producing substances of 300 to 400 ppm for brewery water.

The following is quoted from the California Water Pollution Control Board's summary of irrigation water supply:

> "Absolute limits to the permissible concentration of salts in irrigation waters cannot be fixed, for several reasons (A.W.W.A., 1940):

(a) It is almost universally true that the soil solution is at least three to eight times as concentrated as the water that replenishes it, because of the evaporation of water from the soil surface, transpiration of plants, and the selective absorption of salts by the plants.

(b) There is apparently no definite relationship between the concentration and composition of the irrigation water and those of the soil solution which, in some cases, may be as much as 100 times more concentrated than the water (Thorne and Peterson, 1949).

(c) Plants vary widely in their tolerance of salinity as well as of specific salt constituents.

(d) Soil types, climatic conditions (such as temperature, rainfall, and humidity), and irrigation practices may all influence the reactions of the crop to the salt constituents.

(e) Inter-relationships between and among constituents may be highly significant; the effect of one ion may be modified by the presence of another. (such antagonistic influences operate between sodium and calcium; boron and nitrates; selenium and sulphates), (Scofield, 1935)."

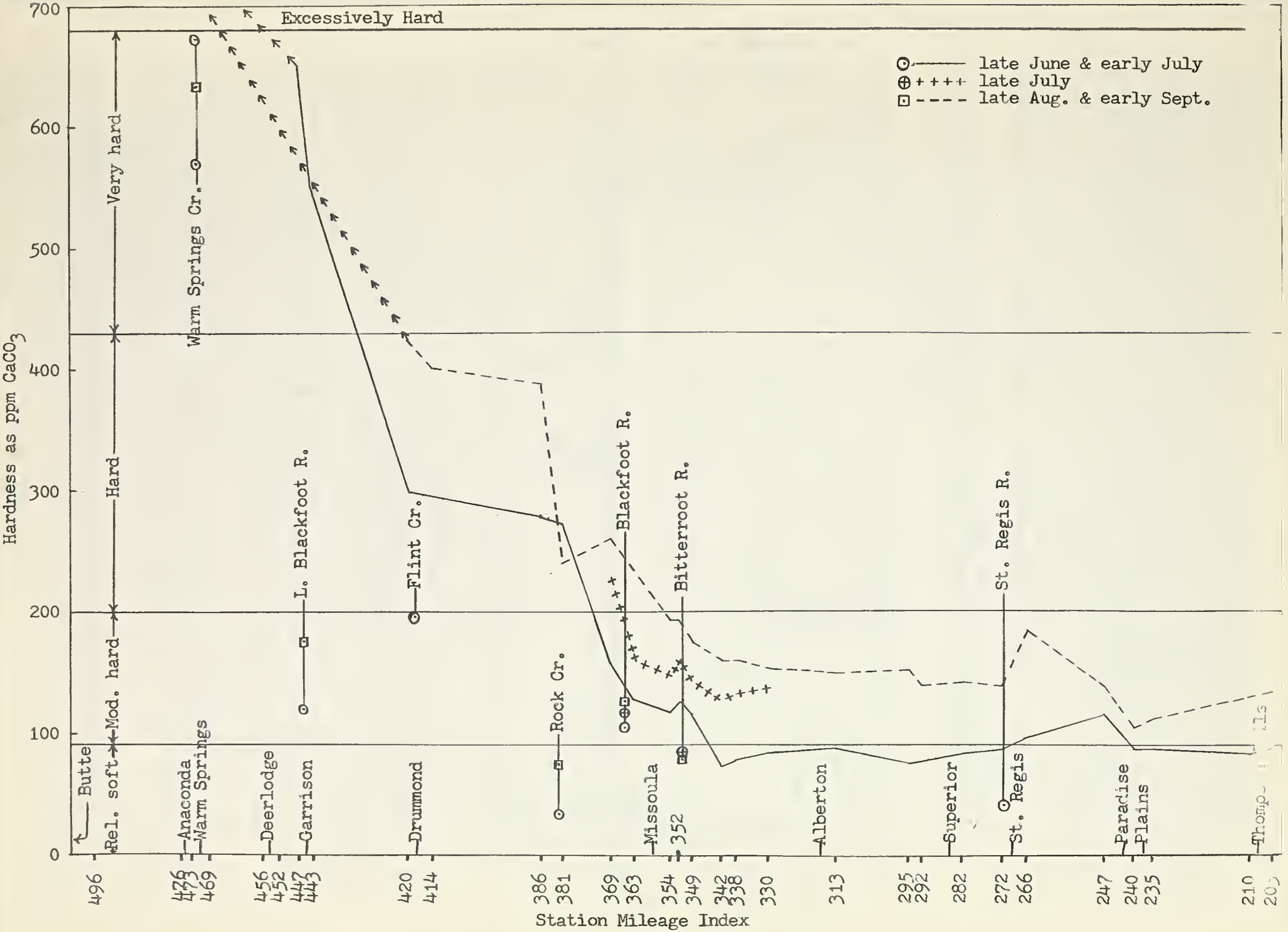
Eaton, et al (1941) statesthat good drainage of the soil may be a more important factor for crop growth than the salt in the irrigation supply. Hard water may be conducive to better development of domestic fowl and livestock (Banks, 1938).

One fisheries worker (Fromemming, 1940) reports that growth of aquaria fish may be limited by the hardness of water, however, this is the only instance known to the author where hard water is reportedly detrimental to fish. In hard waters, toxic metallic ions are less dangerous to fish as shown by information from the upper Clark Fork River above Garrison, which will be presented later.

Results of Hardness Determinations: On the basis of the State Board of Health classification of water according to hardness (Table 2) the Clark Fork above its confluence with the Little Blackfoot River at Garrison is unsuitable for any use except irrigation. (Figure 8). The river from Garrison to its confluencewith the Blackfoot River at Milltown is considered suitable for most uses with proper treatment and softening except as a Class A drinking water source.

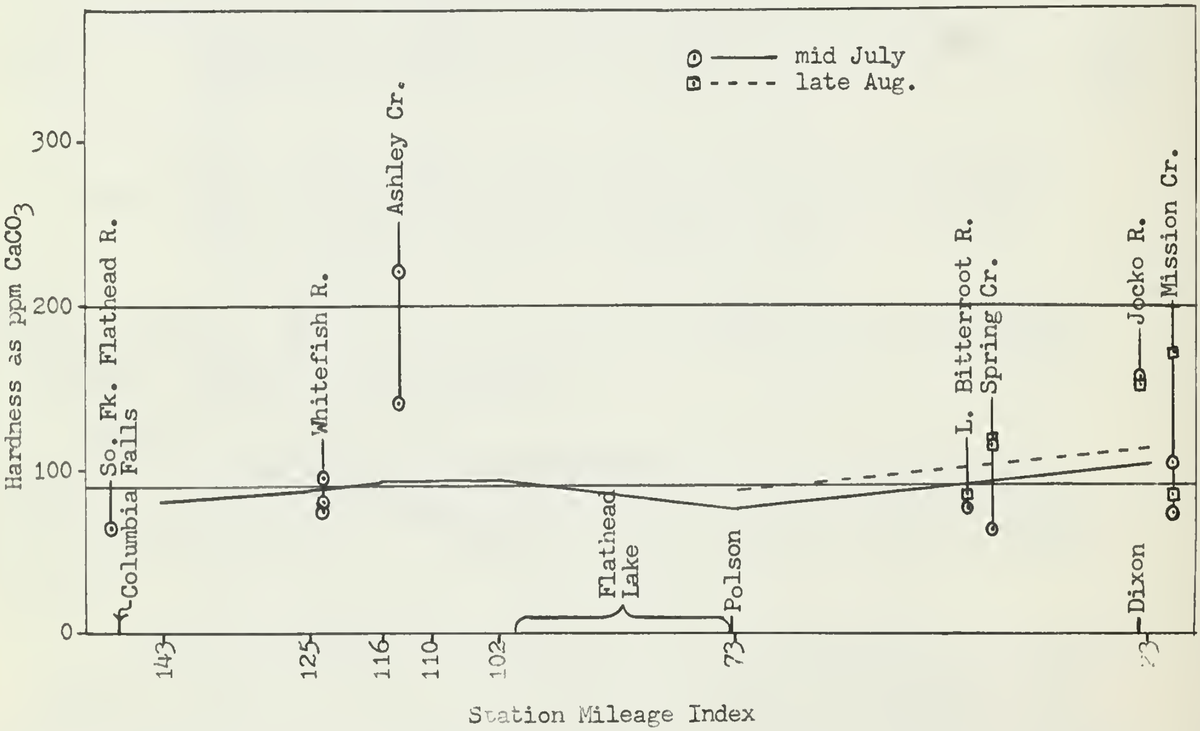
Further dilution by the Bitterroot River below Missoula renders the river water suitable for most uses without softening, and from a point about fifteen miles below Missoula to the Idaho Border, the Clark Fork is a relatively soft to moderately hard source of water (Figure 8).

As with most of the other chemical constituents of natural waters, a seasonal variation in hardness is apparent (Figure 8). Results obtained during late August and early September are higher than those obtained during late June and early July. Samples taken during the latter part of July at Stations 369 to 330 are intermediate between hardnesses found at the same stations in earlier and later collection periods (Figure 8). This lower hardness recorded for late June and early July and its gradual increase is thought to be a result of dilution by surface water runoff during late spring and early summer.


Excessively Hard
⊙—— late June & early July
⊕++++ late July
⊡---- late Aug. & early Sept.
Hardness as ppm $CaCO_3$
700
600
500
400
300
200
100
0
Very hard
Hard
Mod. hard
Rel. soft
Warm Springs Cr.
L. Blackfoot R.
Flint Cr.
Rock Cr.
Blackfoot R.
Bitterroot R.
St. Regis R.
Butte
Anaconda
Warm Springs
Deerlodge
Garrison
Drummond
Missoula
352
Alberton
Superior
St. Regis
Paradise
Plains
Thomp
lls
496
476
473
469
456
452
447
443
420
414
386
381
369
363
354
349
342
338
330
313
295
292
282
272
266
247
240
235
210
205
Station Mileage Index

Hardness determinations indicate that the Flathead River constitutes a relatively soft to moderately hard source of water suitable for most uses without softening (Figure 9). Only one of the tributaries studied (Ashley Creek) was found to have a hardness exceeding 200 parts per million (Appendix C). This station is located below the discharge of the inadequately-treated sewage from Kalispell. A slight increase in hardness was also noted during late summer on the lower Flathead from Polson to Dixon (Figure 9).

Figure 9. Results of hardness determinations from the Flathead River Study Area, 1957.



Hardness of the Kootenai River and one of its tributaries, the Yaak River, in Montana, was found to range from 116 to 144 ppm (Appendix C). Again, this moderately hard source of water is suitable for most uses without softening.

(5) Chlorides: Since sodium chloride is present in urine to the extent of about one percent, the measurement of the chloride ion was included in the standard field analyses conducted.

The U. S. Public Health Service Drinking Water Standards in 1946 recommend that chlorides do not exceed 250 ppm. On the basis of the reported toxicity of chlorides to plants (Doneen, no date) the State Board of Health uses as a guide a maximum allowable concentration of 50 ppm (as chloride) chlorides for waters being used to irrigate alfalfa. In general, allowable limits for chlorides in waters being put to other uses are much higher than this figure; ranging from 400 ppm toleration limits for trout to 4000 for livestock (Adams, 1940). The State Board of Health considers 1500 ppm as excessive for humans.

Findings ranged from 0 to 26 ppm expressed as chloride (Appendix C, with no apparent correlation between chlorides and the discharge of raw sewage into the streams of the study area. In fact, early and late summer results conflicted with the earlier determinations, being higher than those made during late summer (Figure 10). The latter is in direct conflict with seasonal variations apparent in concentration levels of other chemical constituents. As with percentage dissolved oxygen saturation, interpretation of the results of chloride analysis must be based on a daily variation curve in order for chloride concentrations to lend any significant support to water pollution surveys. For this reason, no attempt is made here to interpret the results of chloride analysis.

No chloride concentrations above the 50 ppm limit were recorded at any of the sampling stations in the study area, with the highest content of 26 ppm found below Missoula on the Clark Fork River (Appendix C).

(6) Sulphates: Concerning the occurrence and importance of sulphates in water, the following is quoted from the California Water Pollution Control Board's summary of pertinent literature on the subject: "Sulphates occur naturally in waters, particularly in the western U.S. as a result of leachings from gypsum and other common minerals. They may also occur as the final oxidized stage of sulphides. For example, iron pyrite (FeS) may be leached from mines and the sulphide ions oxidized in surface streams to sulphates (Colmer and Hinkle, 1947)."

Since a high sulphate content was suspected in some of the streams, particularly those in the vicinity of Butte which drain from mining and milling areas, water samples for analysis of sulphates and other cations and anions closely associated with mining and milling were collected.

The USPHS Drinking Water Standards of 1946 recommend a maximum of 250 ppm allowable sulphate for interstate waters except where a more suitable supply is available. In Montana, a limit of 1800 ppm has been accepted for human consumption. This limit is based on a laxative action toward users. This limit is much higher than the recommended maximum for most other uses of water. Recommended limits for some industrial uses of water including brewing, carbonated beverages, concrete, ice making, photography, and sugar making range from 20 to 250 ppm (California Water Pollution Control Board, 1952, revised 1957). Sulphates appear to increase the corrosiveness of water toward concrete and Kellam (1933) states the following regarding this: "If the SO_3 is less than 25 ppm, injury from this source will be mild and inconsequential. When the SO_3 is in the hundreds of ppm, it is a possible source of great harm and protection must be provided". Hammerton (1945) claims that there will be little attack if the sulfate concentration is less than 300 ppm (as SO_3) but if the sulfate is greater than 1000 ppm, attack will be rapid (Rudolf, 1930). In high concentrations, sulfate ions may cause the precipitation of calcium and may in themselves be toxic to plants (Kelly, et al, 1939). Scofield (1935) suggests the following classification of irrigation waters with regards the sulfate content: less than 192 ppm - excellent; 192 - 336, good; 336 - 576, permissible; 576 - 960, doubtful; over 960 ppm, unsuitable. In U. S. waters that support good game fish populations, five percent of the waters contain less than 11 ppm sulfates, 50 percent less than 32 ppm, and 95 percent less than 90 ppm. (Hart, et al, 1945).

Results of Sulphate Analysis: In order to simplify the graphical presentation of sulphate analysis, sulphate concentrations found in the Clark Fork drainage study area were converted to logarithms (Base 10) and are presented in Figure 11.

Figure 10. Chloride determinations from the Clark Fork Study Area, 1957.

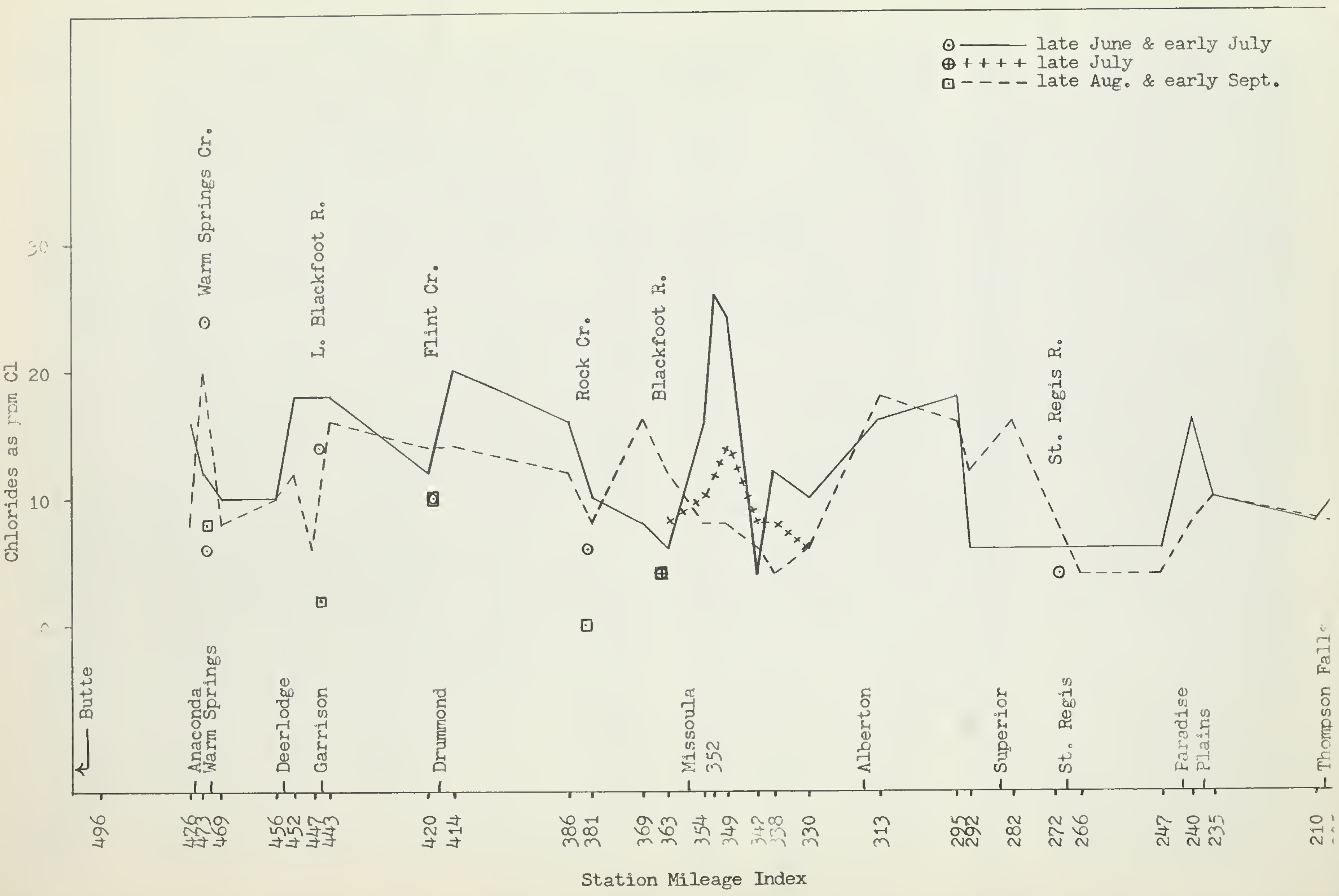
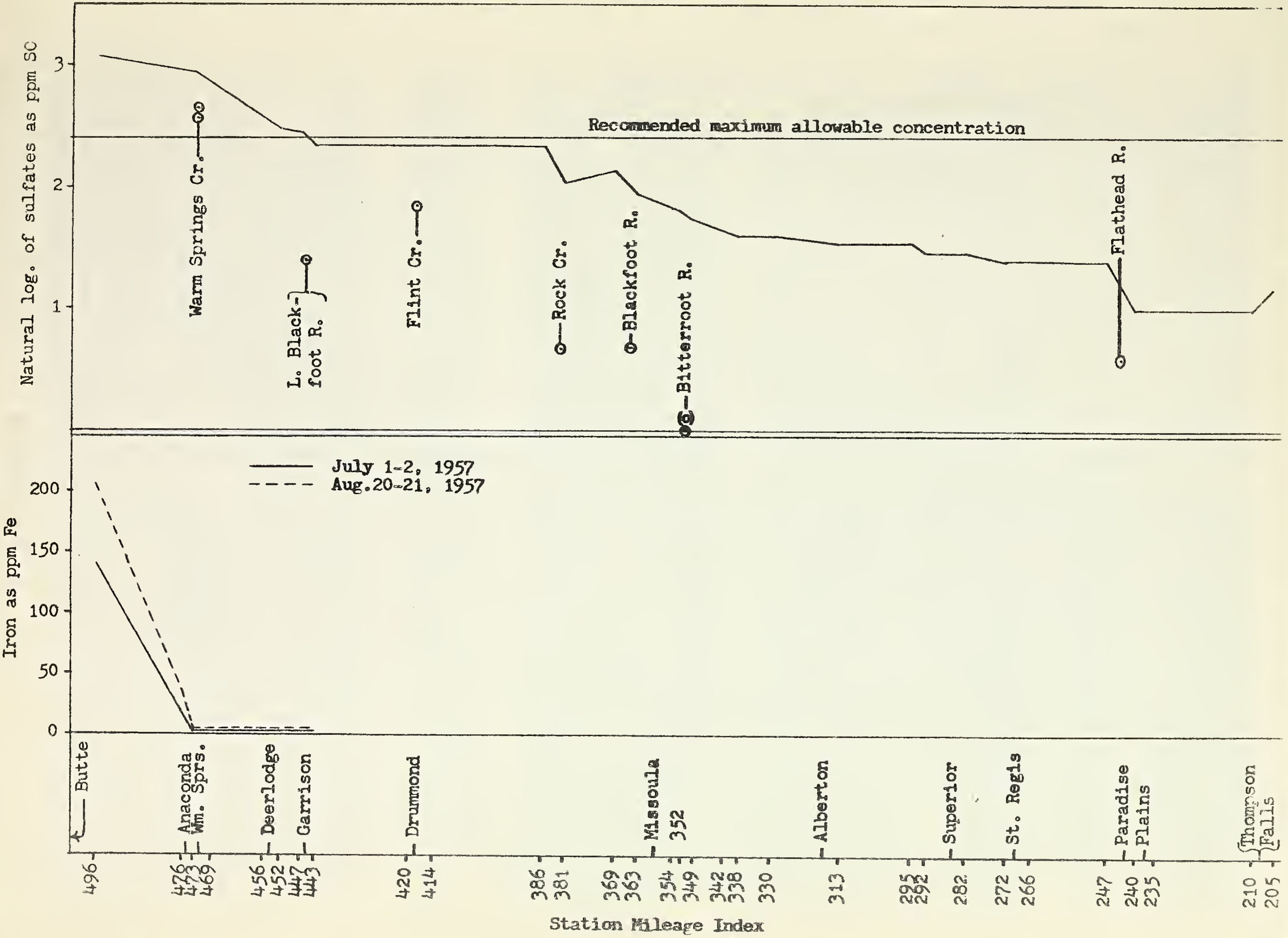


Figure 11. Results of sulphate and iron analyses from the Clark Fork Study Area, 1957.



The sulphate content of the Clark Fork River above the Little Blackfoot River, and lower Warm Springs Creek exceeds the U. S. Public Health Service recommended maximum for drinking water, while the remainder of the Clark Fork drainages and those tributaries studied are well below the suggested maximum (Figure 11).

Sulphate concentrations of the waters studied in the Flathead and Kootenai Drainage Area and their tributaries are again well below the suggested maximum of 250 ppm. (Appendix D).

(7) Phosphates: Phosphate analyses were conducted by the State Board of Health Chemistry Laboratory at most of the stations in the Clark Fork-Flathead-Kootenai study area, and results indicate that the concentration of phosphates in the waters of these drainages would not hinder the use of the water for any of the recognized legitimate uses now being placed upon these waters. Phosphate concentrations ranged from 0 to 0.24 ppm. (Appendix D) and were the highest in Ashley Creek near Kalispell. These concentrations of phosphates would have no affect upon the domestic use of the water and would become significant only in their relation with other nutrients dissolved in the water. These total nutrients resulting from organic wastes can cause excessive blooms of algae which, in turn, can deplete the concentration of dissolved oxygen in the natural waters involved. However, until more is learned about the 24-hour dissolved oxygen cycle in the various waters of the study area, no conclusion can be drawn concerning phosphates in this respect.

(8) Iron, Lead, Zinc, Copper and Arsenic: Water samples for analyses of lead, iron, zinc, copper and arsenic were collected and submitted to the State Board of Health Chemistry Laboratory for determination. Samples for these analyses were collected only from the Upper Clark Fork at Station 496 (Silver Bow) to Station 493 (below Garrison). The concentration of iron is presented in graphical form (Figure 11) as an example showing the affect of the new treatment pond constructed near Warm Springs by the Anaconda Company. It is noted that the concentration of lead, zinc, copper and arsenic (Appendix D) follows this same trend and that the treatment by this large waste stabilization pond is very effective in reducing the high concentrations of these minerals to a minimum.

Iron: With regards the affect of iron on the various uses of the water and the recommended maximums being applied throughout the United States and in the various States, the following is condensed from the California State Water Pollution Control Board publication "Water Quality Criteria" (1957).

The U. S. Public Health Service Drinking Water Standards in 1946 suggest a limit of 0.3 part per million for the sum of the iron and manganese in water used for drinking purposes. These limits are not based upon physiological considerations (Kehoe, et al, 1944, Muehlberger, 1951), instead the limit is based upon the esthetic considerations since these materials tend to stain laundry and porcelain fixtures (Foulk, 1925). In concentrations higher than one-half to one part per million, they can be tasted. When domestic water supplies contain iron, trouble may be experienced with the growth of Crenothrix and other iron bacteria. Normally, trouble with Crenothrix may be experienced when iron exceeds 0.2 ppm (Thresh and Beale, 1925). Regarding the industrial use of water, recommended threshold values for baking, brewing, food processing, pulp and paper making, and sugar making range from 0.1 to 0.3 ppm. Iron is considered of minor importance with regards irrigation water and becomes significant only when cattle will not drink enough water to maintain milk production if the water contains a high concentration of iron (Taylor, 1935). The threshold concentration for the lethality of iron to fish has been reported as low as 0.2 ppm (Minkina, 1946). Ten ppm iron will cause serious injury or death to rainbow trout within five minutes (Ebeling, 1928). Ellis (1937) reports that, of the waters which support a good fish population in the United States, five percent contain no iron, 50 percent contain less than 0.3 ppm iron, and 95 percent contain less than 0.7 ppm.

The concentration of iron would exert a detrimental effect toward the use of the Clark Fork from Butte at least to Garrison, for most of the purposes mentioned above (Figure 11). The concentrations of iron found, however, would not restrict the use of the water as a source of irrigation water and it is known that game fish (brown trout) were present in the study area at the time collections were made. It is thought that the antagonistic effect of calcium on the heavy metal ions renders this water suitable for game fish residence. It is questionable, however, that resident game fish populations can be successfully maintained since iron is more toxic to trout eggs than to adult fish (Ellis, 1937).

Lead: With regards the effect of lead upon the various uses of waters in the study area, it should first be pointed out that lead is a cumulative poison, that is, lead can build up to lethal concentrations in the vital organs of the human body if continuously consumed over a long period of time. The exact level at which the intake of lead by the human body will exceed the amount excreted has not been established, but it probably lies between 0.3 and 1.0 milligrams per day (American Water Works Association, 1950). Lead in an amount of 0.1 milligram ingested daily over a period of years has caused lead poisoning (Wright, et al, 1928 and Spitta, 1933) and the daily ingestion of 0.2 milligrams is considered excessive (Kehoe, 1948). A case of lead poisoning among human beings is reported to have occurred at a very low concentration of 0.042 ppm (Thresh & Beale, 1925). The Public Health Service has established a limit of 0.1 ppm lead to be used as a recommended standard for interstate drinking waters. Most authorities agree that 0.5 ppm of lead is the maximum safe limit for this cation in a potable supply for animals (Pierse, 1938). Concentrations of lead ranging from 0.1 to 0.75 ppm are reported to be toxic to fish, however, calcium in a concentration of 50 ppm has been known to destroy the toxic effect of 1 part per million of lead (ORSANCO, 1950).

Results of the analyses for lead indicate that the concentrations of this metal in the water would not restrict the use of the water of the upper Clark Fork from any of its legitimate uses recognized by the Water Pollution Control Council and the State Board of Health.

Zinc: The U. S. Public Health Service Drinking Water Standards of 1946 set a limit of 15 parts per million of zinc in acceptable water supplies when no alternate water supplies are available. Prior to 1946, the limit had been five ppm, but this restriction was liberalized because zinc has no known adverse physiological effects upon man. A summary of the literature relating to the toxicity of zinc (Bartow and Weigle, 1932; Anderson, et al, 1934) reveals that families in communities have used waters containing 11.2, 17, 18.5 and 26.6 parts per million with no ill affects. From esthetic considerations, however, high concentrations of zinc in domestic waters are undesirable. All readily soluble salts of zinc have an unpleasant, astringent taste, and can be detected in less-than-dangerous amounts in drinking water (Drinker & Fairhall, 1933). Further literature review suggests that waters containing less than the 15 part per million recommended maximum concentrations of zinc would not adversely affect the use of such water as a source of industrial and stock water or irrigation water. Much lower concentrations of zinc, however, are reported as being lethal to fish and other aquatic life.

In soft water, concentrations of zinc, ranging from 0.1 to 1.0 ppm have been reported to be lethal but calcium is antagonistic towards such toxicity. Jones (1938) reports that for mature fish, the lethal limit for zinc in water containing 1.0 ppm of calcium is only 0.3 ppm, but in water with 50 ppm of calcium, as much as 2.0 ppm of zinc is not toxic.

None of the samples of water from the stations studied in the upper Clark Fork were found to contain more than the recommended minimum concentration of 15 ppm and the concentrations of zinc at the uppermost stations (496, Silver Bow; 476, above the new Anaconda Company settling pond; and 473, immediately below the new settling pond) would be considered too high to sustain sport fish life. Again, however, the high concentration of calcium in the water undoubtedly serves to minimize the toxic effects of zinc toward game fish.

Copper: Copper is not considered to be a cumulative systemic poison like lead. Most of the copper ingested is excreted by the body. Very little is retained. It is believed that a normal daily diet may provide as much as 20 milligrams, and that a man weighing 60 kilograms can take one gram of copper per day safely (A.W.W.A., 1950 & Hale, 1942). The U. S. Public Health Service Standard for copper was raised in 1942 from 0.2 to 3.0 ppm. Regarding the use of waters containing copper for irrigation purposes, 0.17 to 0.20 ppm have been reported as toxic to sugar beets and barley (Broyer and Furnstall, 1945). The toxicity of copper to aquatic organisms varies greatly with the species involved and with the chemical characteristics of the water. The toxicity of copper salts in hard water is greatly reduced. Concentrations of 0.015 to 3.0 ppm have been reported as toxic to many kinds of fish, crustacea, molluscs, insects, phytoplankton, and zooplankton in soft water (Czensny, 1934; Jones, 1938; Podubsky & Stedronsky, 1948; ORSANCO, 1950; and Rudolfs, et al, 1950).

Again, the waste stabilization pond located near Warm Springs acts to reduce the relatively high concentrations of copper to trace or undetectable amounts below the waste stabilization pond. (Appendix D). The only stations exceeding the recommended 3.0 ppm limits are above the point on the Clark Fork which is exempt from classification by law. Concerning the Clark Fork River below the Warm Springs settling pond, the extreme hardness and high total dissolved solids undoubtedly reduces the toxicity of copper to aquatic organisms to a minimum.

Arsenic: Elemental arsenic is insoluble in water. Many of its compounds are highly soluble. Arsenic is found in small amounts in body tissues (Maynard, 1947), but in excess it is considered relatively toxic to man. The U. S. Food and Drug Administration permits a maximum of 1.43 ppm in food (Negus, 1938) but the U. S. Public Health Service suggests a limit of 0.05 ppm (U.S.P.H.S., 1946). Chronic arsenosis is of slow onset, and may not become apparent for two to six years. In water taken over a long period of time, the following concentrations of arsenic have been recorded as poisonous to human beings: 0.21 ppm (Fairhall, 1941), 0.3 to 1.0 ppm (Bada, 1939), and 0.4 to 10 ppm (Wyllie, 1937 & Fairhall, 1941). The tolerance of plants, livestock and fish and other aquatic life exceeds the Public Health Service recommended limit 0.05 ppm and concentrations of 2 to 4 ppm of arsenic are reported as not interfering with the selfpurification of streams (Rudolfs, et al, 1944).

Again, the concentration of this metal is greatly reduced by the waste stabilization pond to concentrations believed to be nondetrimental toward the uses of the Clark Fork River below the settling ponds near Warm Springs (Appendix D).

(9) Water Temperature: In the past throughout this state, temperature has not been of great concern. However, the effect of rises in water temperature upon the reaction of other pollutants in a natural body of water is a problem of considerable importance. Some of these adverse **effects** have been mentioned before with regards the role of dissolved oxygen and the increased toxicity of many materials toward aquatic organisms coincident with a rise in temperature.

The following review is an attempt to convey the role of temperature in stream ecology to the reader:

When a rise in temperature occurs in a stream polluted by organic matter, there is not only a decrease in the amount of dissolved oxygen, due to the lower solubility of the gas at the higher temperature, but also an increased rate of utilization of dissolved oxygen by biochemical reactions which proceed much faster at higher temperatures. According to Ruttner (1926) the oxygen consumption of aquatic fauna nearly doubles for each 10 degree C. rise in temperature. For these reasons, many rivers may be satisfactory with regard dissolved oxygen content in the winter, but may contain little or no oxygen during the summer. Of course, if the dissolved oxygen does fall to zero, putrefaction of organic matter will occur, giving rise to odors and nuisance conditions (Klein, 1957).

Trout are affected by a rapid rise in temperature and there may even be mortality among the more sensitive game fish. A report by the Ministry of Health of Great Britain (1949) lists the lethal maximum temperature for trout as being 22 degrees C. (72 degrees F.) while in this country, a temperature of 83 degrees F. has been reported to be about the upper limit for certain trout species (California WPC Bd., 1957). In a survey of the Willamette River (Dimick and Merryfield, 1945), no salmonoid fish were found at temperatures above 73 degrees F. but were reported healthy at 72 degrees. Water with maximum temperatures of 55 to 60 degrees F. support the majority of the salmonoid fish.

For drinking purposes, water with a temperature of 50 degrees F. is usually satisfactory, while temperatures of 60 degrees or higher are objectionable. (Calif. WPC Bd., 1957). Whipple, quoted by Burnson (1938), has reported that temperatures above 65 degrees F. cause complaint from most consumers. Increased temperatures may also stimulate growth of taste and odor producing organisms in lakes and impoundments (Hale, 1923; Kofoid, 1923; Rosenberg, 1939; Findenegg, 1942; Thompson, 1944; and Silvey, et al, 1950). In general, the survival time of infectious bacteria and other pathenogenic organisms is reduced, however, with increasing water temperatures (Berry, 1934; Heukelekian & Schuthoff, 1936; Beard, 1938; Peretz & Medvinskaya, 1946; Chang, et al, 1948; Newton 1948; and Rudolfs, et al, 1950). Most industrial uses of water require temperatures below a maximum of 75 degrees F. with an optimum temperature requirement of 55 degrees F. (Taylor, 1935; Baker, 1944; Habbart, 1945; Wolman, 1948; and Chem. Eng., 1949). Warm water accelerates corrosion in pipelines and cooling systems (Calif. WPC Bd., 1957). With regard to swimming and other recreational uses of water, rising temperatures stimulate the decomposition of sludge, formation of sludge gas, multiplication of saprophytic bacteria and fungi (particularly in the presence of organic wastes), and the consumption of oxygen by processes of putrefaction, thus affecting the esthetic value of the area as well as leading to fish kills (Viehl, 1950).

Results of Water Temperature Determinations: In order to estimate maximum temperatures from those temperatures obtained at the various sampling stations throughout the study area (Appendix C), the latter were applied to the 24-hour temperature variation curve recorded for three stations located on the Clark Fork below Missoula (Stations 342, 338 and 330). The daily variation curve is pictured in Figure 12 and estimated maximum temperatures from this curve are given in Table 3.

Estimated water temperatures of most of the streams studied exceed the optimum recommended temperatures for drinking water. Several of the streams or portions of streams were found to either approach or exceed the recommended maximum for trout. These streams or portions of streams are mostly located in the lower Clark Fork and the Flathead drainage and include the Whitefish River, Ashley Creek and the Flathead River below Kerr Dam and above its confluence with the Clark Fork River (Table 3). The synergistic effect of increasing water temperature upon the toxicity of poisonous substances discharged to these streams or portions of streams must be considered of prime importance in the future use of these waters.

Estimated maximum temperatures of the Clark Fork River and its major drainages excepting the Flathead River are graphically illustrated in Figure 13. It will be noted that a general trend in temperature is followed from a high in the uppermost part of the drainage to a depression around Missoula and then a gradual rise again in the lower Clark Fork. The high temperatures noted in the section in the Clark Fork between Flint Creek and Rock Creek are believed to result from the discharge of natural warm water springs in this area to the river.

Figure 12. Average water temperature variation recorded at three stations on the Clark Fork River 12-20 miles downstream from Missoula, Aug. 1-2, 1957.

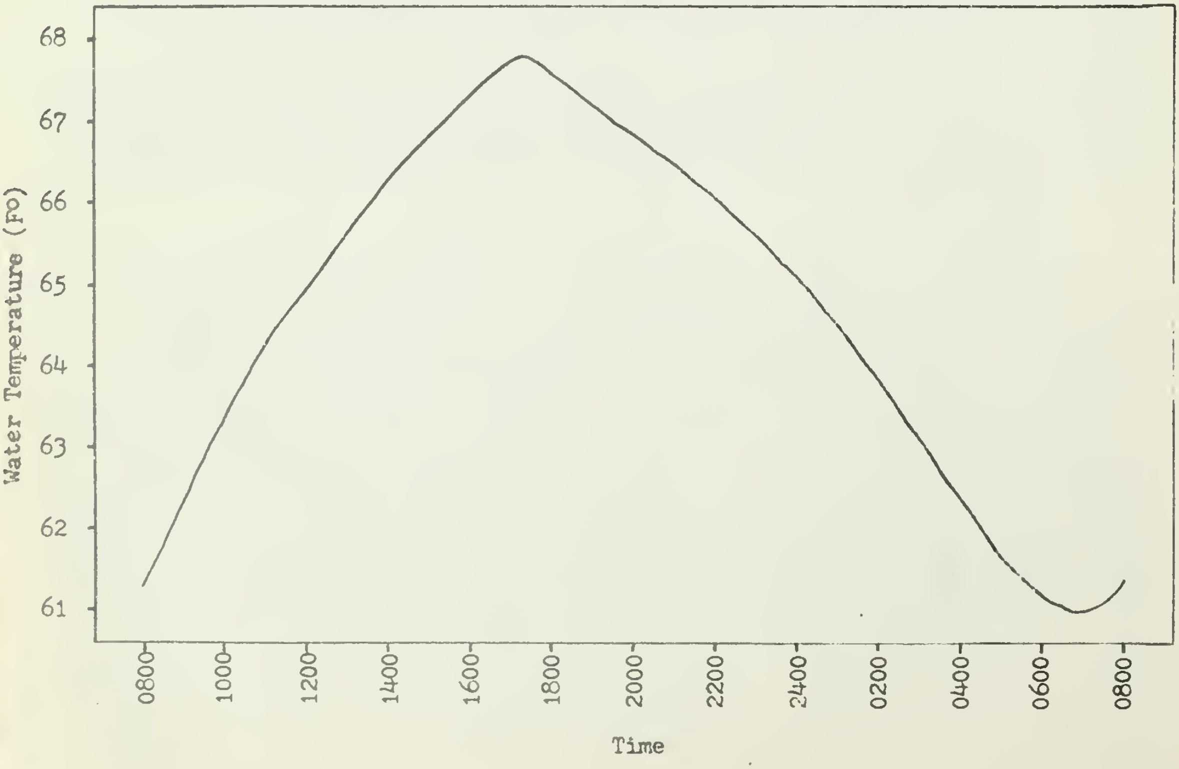


Figure 13. Estimated maximum water temperatures of the Clark Fork Study Area, 1957.

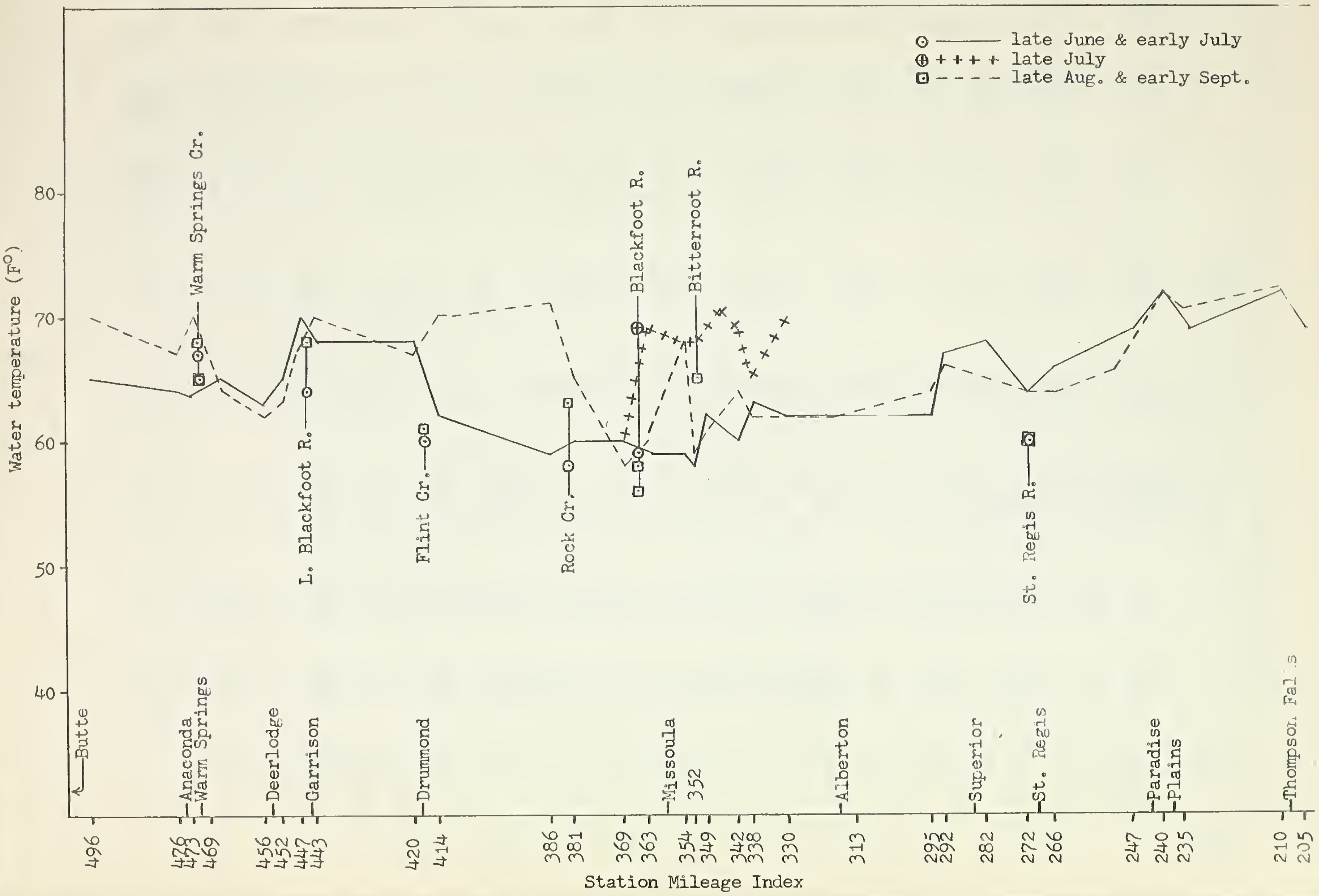


Table 3. Estimated maximum water temperatures from sampling stations in the Clark Fork-Flathead-Kootenai Study Area, 1957.

CLARK FORK-FLATHEAD DRAINAGE

Station number	Date	Time	Actual temp. (F°).	Est. Max. temp.
496	7/1	1100	62	65
	8/20	1045	66	70
476	7/1	1600	64	64
	8/20	1145	64	67
473	7/1	1715	64	64
	8/20	1640	70	70
472-4.0	7/1	1320	65	67
	8/20	1400	64	65
469	7/2	0830	60	65
	8/21	0830	59	64
456	7/2	0930	59	63
	8/21	1000	58	62
452	7/2	1100	62	65
	8/21	1220	61	63
447	7/2	1450	69	70
	8/21	1400	67	68
445-2.0	7/2	1200	62	64
	8/21	1530	67	68
443	7/2	1530	67	68
	8/21	1630	70	70
420	7/3	1300	66	68
	8/22	0845	62	67
418-26	5/17	1430	44	45
418-24	5/17	1600	49	49
418-22	5/17	1800	55	55
418-13	5/17	1700	54	54
418-20	7/3	1500	59	60
	8/22	1030	58	61
414	7/3	1715	62	62
	8/20	1330	68	70
386	7/4	0700	58	64
	8/22	1500	70	71
382-2.0	7/3	1930	57	58
	8/23	0900	58	63
381	7/4	1000	56	60
	8/23	1030	61	65
369	6/26	1000	56	60
	7/26	1030	57	60
	9/3	1300	56	58
363	6/26	1300	57	59
	7/26	1230	67	69
	9/3	1500	59	60
354	6/26	1400	58	59
	7/31	1500	67	68
	9/5	1600	68	68
352	6/26	1600	58	58
	7/29	1130	65	68
	9/6	1830	54	59
351-46	8/19	0930	58	62
351-40	8/19	1400	58	59
351-27	8/16	1000	61	65
	9/9	1000	56	60
351-24	8/16	1400	65	66
	9/9	1430	57	58
351-1.0	8/19	1630	68	68
	9/6	1345	64	65
349	6/27	0900	57	62
	7/29	1400	70	71
	9/6	1100	58	61
342	6/27	1230	58	60
	7/30	1000	65	69
	9/5	1045	61	64

Station number	Date	Time	Actual Temp. (F°)	Est. Max. temp.
338	6/28	0900	58	63
	7/30	1600	65	65
	9/5	1330	61	62
330	6/27	1430	61	62
	7/31	1200	67	70
	9/5	0900	57	62
313	6/28	1100	59	62
	9/4	0930	58	62
295	6/28	1300	60	62
	9/4	1330	62	64
292	7/9	1030	63	67
	8/26	1115	63	66
282	7/9	1400	67	68
	8/26	1330	63	65
272	7/9	1700	64	64
	8/26	1530	63	64
271-3.0	7/10	1000	56	60
266	7/10	1300	64	66
	8/27	0730	58	64
247	7/11	0900	64	69
	8/15	1430	65	66
244-149-3.0	7/25	1200	67	70
244-143	7/25	1400	67	68
244-125	7/24	0900	60	65
244-123 2.0-15	7/24	1630	70	70
244-123-2.0-11	7/24	0900	69	75
244-123-2.0-2.0	7/24	1100	67	70
244-116	7/23	1600	59	59
244-114-15	7/23	1300	70	72
244-114-9.0	7/23	1730	74	74
244-110	7/23	1130	64	67
244-102	7/23	1000	63	67
244-73	7/17	0900	68	74
	8/28	0915	67	72
244-45 21	7/16	1320	68	70
	8/27	1440	61	62
244-45-19	7/16	1530	70	71
	8/27	1330	61	62
244-42-10-5.0	7/17	1300	56	58
	8/28	1400	53	54
244-42-10-2.0	7/17	1500	60	61
	8/28	1600	55	55
244-24-2.0	7/22	1200	64	67
	8/29	1400	58	59
244-23	7/22	1100	67	70
	8/29	1230	60	62
244-20-9.0-6.0	7/22	1600	58	58
	8/29	0800	54	59
244-20-9.0-3.0	7/22	1400	64	65
	8/29	1000	52	55
240	7/11	1040	68	72
	8/15	1130	68	72
235	7/11	1400	68	69
	8/15	1000	67	71
210	7/12	1000	68	72
205	7/12	1400	68	69
	8/15	0745	66	73

Table 3. (Continued).

Station number	Date	Time	Actual Temp. (F^{o})	Est. Max. temp.
		Kootenai Drainage		
265	8/13	1330	59	60
262-9.0	8/13	0730	49	54
262-5.0	8/13	1045	53	56
257	8/13	1500	59	60
204	8/14	0800	57	63
198	8/14	1030	59	62

(10) Turbidity: The turbidity of water is attributable to suspended and colloidal matter, the effect of which reduces clearness and the penetration of light. The turbidity of the water sample is a measure of the extent to which the intensity of light penetration is reduced by suspended matter. The term turbidity is sometimes used synonymously with suspended solids, however, the degree of turbidity is not equal to the concentration of suspended solids, but rather is an expression of the effect of suspended solids upon the quality of the water. The standard unit of turbidity is considered as that produced by 1 ppm of silica in distilled water.

The U. S. Public Health Service Drinking Water Standards of 1946 specify that the turbidity of filtered water shall not exceed 10 ppm (silica scale) but for unfiltered water or raw water sources no quantative requirements are set. The State Board of Health uses this standard as a guide for drinking water and suggests that waters exceeding this limit for sustained periods of time be filtered. A limit of 10 ppm turbidity is recommended for many industrial uses of water including beverage and food processing, brewing, baking and ice making and a limit of 50 ppm is suggested for cooling water (California State Water Pollution Board, 1957). Excessive turbidity adversely affects fish production since it interferes with the growth of plants important in the fish food cycle by reducing the penetration of sunlight in water. The important game fish species in Montana, trout, salmon, whitefish and bass, require clean water and increasingly turbid water reduces the numbers of these fish if the turbidity is of a permanent nature. Other fish species, such as the sauger, sheepshead, catfish and carp seem to thrive in turbid waters. Much study concerning the toleration limits of game fish to turbidity has been carried out in other parts of the country, however, no such studies have been made in Montana. It is hoped that in the near future such a study can be conducted in this state.

Results of Turbidity Determinations: Most of the streams of the study area were found to have turbidity readings of less than 10 ppm during the period of investigation. Notable exceptions were the Clark Fork River above the Warm Springs settling ponds and the Little Bitterroot River near Hot Springs. The Anaconda Company settling pond reduced the turbidity of the

Upper Clark Fork to less than 10 from 115 - 340 ppm (Appendix C). Dilution of the Little Bitterroot by the Flathead River reduced the turbidity to 11 ppm twenty-two miles below the confluence of the Little Bitterroot with the Flathead River and was apparently much higher between these two points. The Flathead above the mouth of the Little Bitterroot was found to be less than 7 ppm with the exception of the station located below Ashley Creek near Kalispell at which the turbidity was 28 ppm (Appendix C). Other stations in the study area exceeding the 10 ppm suggested limits for unfiltered water supplies for drinking purposes are the Clark Fork River below Warm Springs, below Deer Lodge, above Garrison, near East Missoula, below Alberton, near Forest Grove and between Alberton and Superior; Flint Creek below Philipsburg to Maxville; the Whitefish River below Whitefish and above the Flathead River; the Flathead River below Whitefish and above Ashley Creek; and Ashley Creek below Kalispell (Appendix C). If water from these streams or sections of streams were to be used as a source of drinking water, filtration would be suggested.

BACTERIAL PROCEDURES AND RESULTS

Water samples for analysis of most probable number coliform organisms were collected at least once during the study period at most of the sampling stations in the study area and submitted to the State Board of Health Bacteriology Laboratory for determination. Standard Methods for the presumptive and confirmed tests for coliform organisms were followed and the estimation of coliform group density was made from these tests (Appendix F).

The following is a condensation of the California State Water Pollution Control Board's summary of pertinent literature dealing with the role and use of coliform bacteria in water supply and water pollution control work.

Water is examined for the indications of excretal or sewage pollution. When it is found, the water is considered as potentially dangerous. The demonstration of the presence of coliform organisms in a water sample is regarded as evidence of fecal pollution and serves as a basis of water quality criteria.

The coliform group of organisms includes by definition, "all aerobic and faculative, anaerobic, Gram-negative, nonspore-forming bacilli which ferment lactose with gas formation (Standard Methods, 9th Edition).

Other potential indicator organisms such as streptococci (Standard Methods, 9th Edition; AWWA, 1950) and others (Ministry of Health, 1928; Mallman and Galpi, 1930) have been suggested to supplant or supplement the coliform test, but neither the organisms nor the techniques have yet been proven more satisfactory for general use and the coliform test still remains the most practical one, although better and more rapid procedures are constantly being sought.

Coliform organisms may gain access to water from many sources, primarily among which are excretions from human beings, animals (Foote, 1937), amphibians (Eng. News - Record, 1932 and Hassler, 1932) and birds (Thompson, 1943 and Bidwell and Kelly, 1950); surface runoff; and the multiplication of non-fecal forms on fibrous and vegetable substances in the water. A recommended practice is to rate each individual supply on the basis of frequent examinations, and to suspect at once and investigate any deviations from the usual quality (Standard Methods, 9th Edition).

An effort should be made in practice not to give undue weight to the results of bacterial tests alone, and it is required that the interpretation of water quality should be based on the combined findings of the bacterial examinations and a sanitary survey of the area in question, covering such items as potential sources of pollution and opportunities for self-purification (Prescott, et al, 1936. Standard Methods, 9th Edition; American Journal of Public Health, 1947 and 1949).

The effectiveness of the coliform standards has been demonstrated by the decrease in incidence of waterborne enteric diseases, although the standards adopted have been criticised as arbitrary. Their use has also been justified by studies of the relative death rates of coliforms and enteric pathogens, under natural conditions (Beard and Meadowcroft, 1935; Beard, 1938; Kehr and Butterfield, 1943), and when exposed to various bactericides (Rudolfs, et al, 1950). Under certain conditions, such as different pH values and temperatures, some strains of *Salmonella*, *Shigella*, and *M. tuberculosis* (Snyder, 1951) may be more resistant to disinfectants than the coliforms, particularly *E. coli*. Such data are suggestive that occasionally, as a measure of the effectiveness of purification processes, the significance of the absence of coliforms may be open to doubt (A.W.W.A., 1939; Butterfield, et al, 1943; Watte and Butterfield, 1944; Butterfield and Watte, 1946; and Gershenfeld and Witlin, 1949).

Until 1936, the results of the coliform tests were expressed officially as a coliform index, or *B. coli* index, the reciprocal of the highest dilution in which a positive result was obtained when a geometric series of samples was planted. Since 1936, the numbers of coliforms present have been expressed generally in terms of the most probable number (M.P.N.), a value now regarded as more precise, though still subject to error (Prescott and Winslow, 1936; Standard Methods, 9th Edition). One result of the change in terminology has been some confusion in the literature, especially in engineering review articles; in many papers, also, there is insufficient comprehension of the difference between *B. coli* (coliform organisms) and *E. coli* (*Escherichia coli*) and the two names are often used synonomously (Prescott and Winslow, 1936; Standard Methods, 9th Edition; Phelps, 1948; Peretz and Medvinskaya, 1948; and A.W.W.A., 1950).

The State Board of Health and the Water Pollution Control Council have adopted as objectives the M.P.N. of coliform organisms as suggested by the Pollution Control Council, Pacific Northwest area (Appendix E). This Council is an organization of the sanitary engineers in direct charge of water pollution control programs in Alaska, British Columbia, Idaho, Montana, Oregon, and Washington, with representation of the Canadian Department of National Health and Welfare and the U. S. Public Health Service. The maximum allowable M.P.N. coliform bacterial content of a representative number of samples for the various uses of waters are as follows: *Class A water supply*. Water used for drinking, culinary and food processing purposes without treatment other than simple disinfection and removal of naturally present impurities. The maximum allowable M.P.N. coliform bacterial content should average less than 50 per 100 ml. in any month. *Class B water supply*. Water used for drinking, culinary and food processing with treatment equal to coagulation, sedimentation, filtration, disinfection and any additional treatment necessary for removing naturally present impurities. The M.P.N. coliform bacterial content of a representative number of samples should average less than 2,000 per 100 ml. and should not exceed this number in more than 20 percent of samples examined in any month when associated with domestic sewage. Class C water supply. Water used for bathing, swimming and other recreational purposes. The M.P.N. coliform bacterial content of a representative number of samples should average less than 240 per 100 ml. and should not exceed this number in more than 20 percent of samples examined when associated with domestic sewage. No specific limits for M.P.N. coliform bacteria are given for Class D and E water supplies, i.e. waters used for the growth and propagation of fish and agricultural and industrial water uses. However, an amendment to a Class C water supply has been included with these criteria and states, "when waters are used for recreational purposes such as fishing and boating, exclusive of bathing and swimming, the number 1,000 may be substituted for 240 in statement of coliform objectives under Class C water supplies", (Appendix E).

MPN Coliform Organism Determinations: To facilitate the graphical presentation of results (Figure 14), MPN averages were converted to natural logarithms and the limits of allowable coliform organisms are included with the presentation.

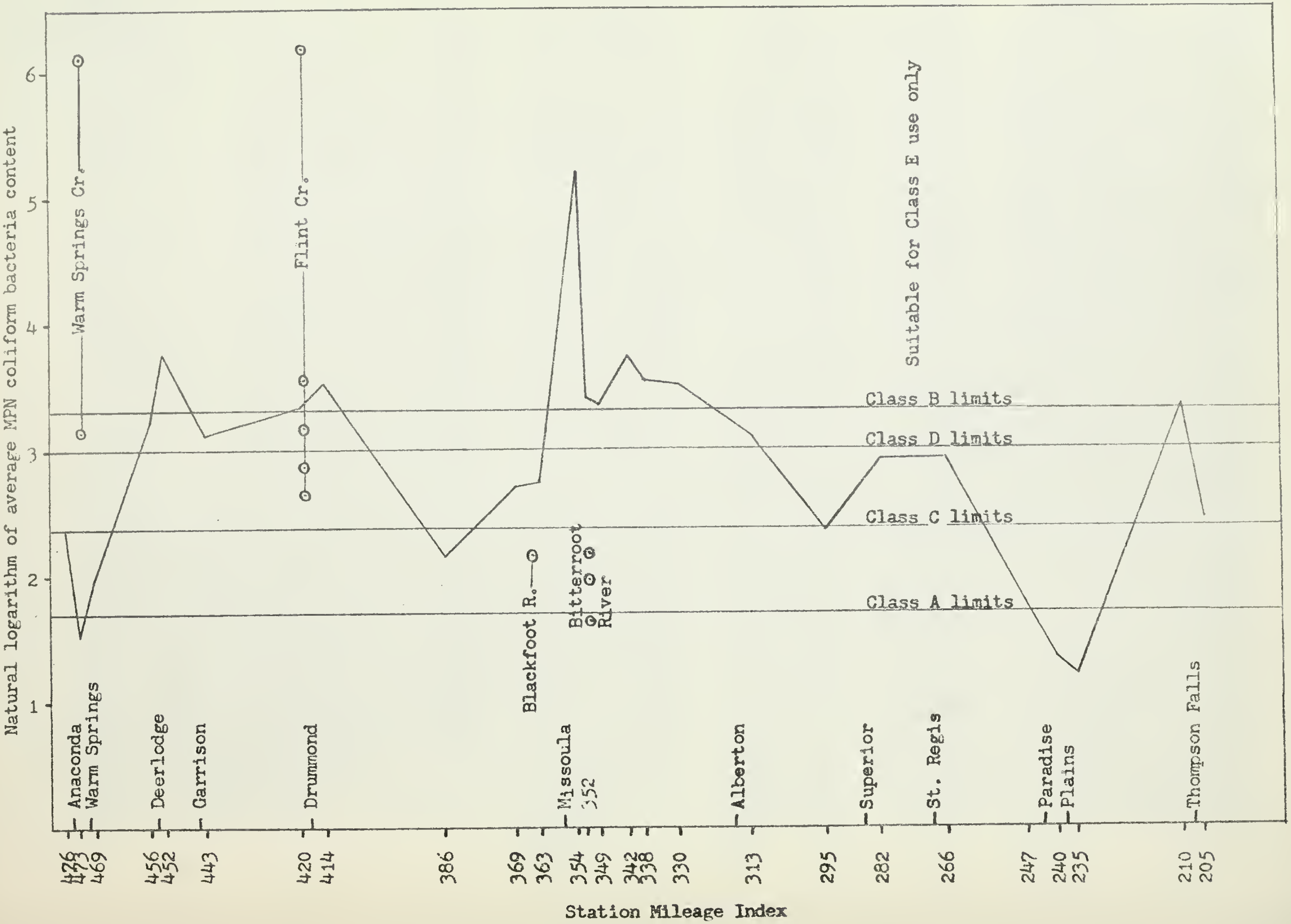
For the purposes of presentation and evaluation of M.P.N. coliform bacteria results, the study area is broken into the following subsections: (1) Clark Fork River from Butte to Warm Springs, (2) Clark Fork River from Warm Springs to the Montana-Idaho border, (3) Warm Springs Creek, (4) Flint Creek, (5) Bitterroot River, (6) Flathead River, (7) Whitefish River, Ashley Creek, Little Bitterroot River, Spring Creek, and Mission Creek, and (8) Kootenai River:

(1) Clark Fork River from Butte to Warm Springs: The coliform indications of fecal pollution at Station 476 (The Clark Fork River above the Anaconda Company settling basin near Warm Springs) and at Station 473 (the Clark Fork below the new settling basin) were relatively low (Appendix F). Probably M.P.N.'s in this area are low as a result of the high concentration of toxic materials introduced to the Clark Fork along with the raw sewage from Butte and Anaconda. This section of the stream is exempt from classification since its primary use has been for industrial waste disposal for a period of over 30 years (Appendix A).

(2) The Clark Fork River from Warm Springs to the Montana-Idaho Border: The M.P.N. bacterial index to raw sewage pollution was found to exceed the limits set by the Board of Health and the Water Pollution Control Council for all four uses of the water for which M.P.N. is a consideration (Figure 14). Only two very short sections of the Clark Fork (main stem) were found to be suitable for the Class A use of water, that is, a water supply used for drinking and culinary purposes without treatment other than simple disinfection. These sections of stream include a three-mile section below the Anaconda Company settling basin at Warm Springs to a point above the entrance of raw sewage from the community of Warm Springs and a seventeen mile section of the river extending from immediately below Station 247 (at the confluence of the Flathead and Clark Fork River near Paradise) to a point six miles below Plains, Montana.

Those sections of river suitable for B, C, D and E uses, that is, water supplies suitable from a standpoint of bacteria for the purposes of drinking with primary and secondary treatment, water supplies suitable for bathing, swimming and recreational purposes, water suitable for the growth and propagation of fish and other aquatic life, and the agricultural

Figure 14. MPN coliform bacteria averages determined for sampling stations in the Clark Fork Study Area, 1957



and industrial use of water, are as follows: The section of the upper Clark Fork between Warm Springs and Deer Lodge, a ten mile section near Station 386 (the Clark Fork above Rock Creek) and the lower Clark Fork in Montana between its confluence with the Flathead River and above Thompson Falls (Figure 14).

Waters suitable only for B, D and E use on the main stem of the Clark Fork River include again the section below the Anaconda Company settling pond near Warm Springs to above Deer Lodge, a forty mile section between Drummond and Missoula, and the river from below Alberton to Thompson Falls.

Portions of the river unsuitable for any use except agricultural and industrial are a twelve mile section below Deer Lodge, a fifteen mile section below Drummond, a forty mile section below Missoula and the river immediately adjacent to Thompson Falls (Figure 14).

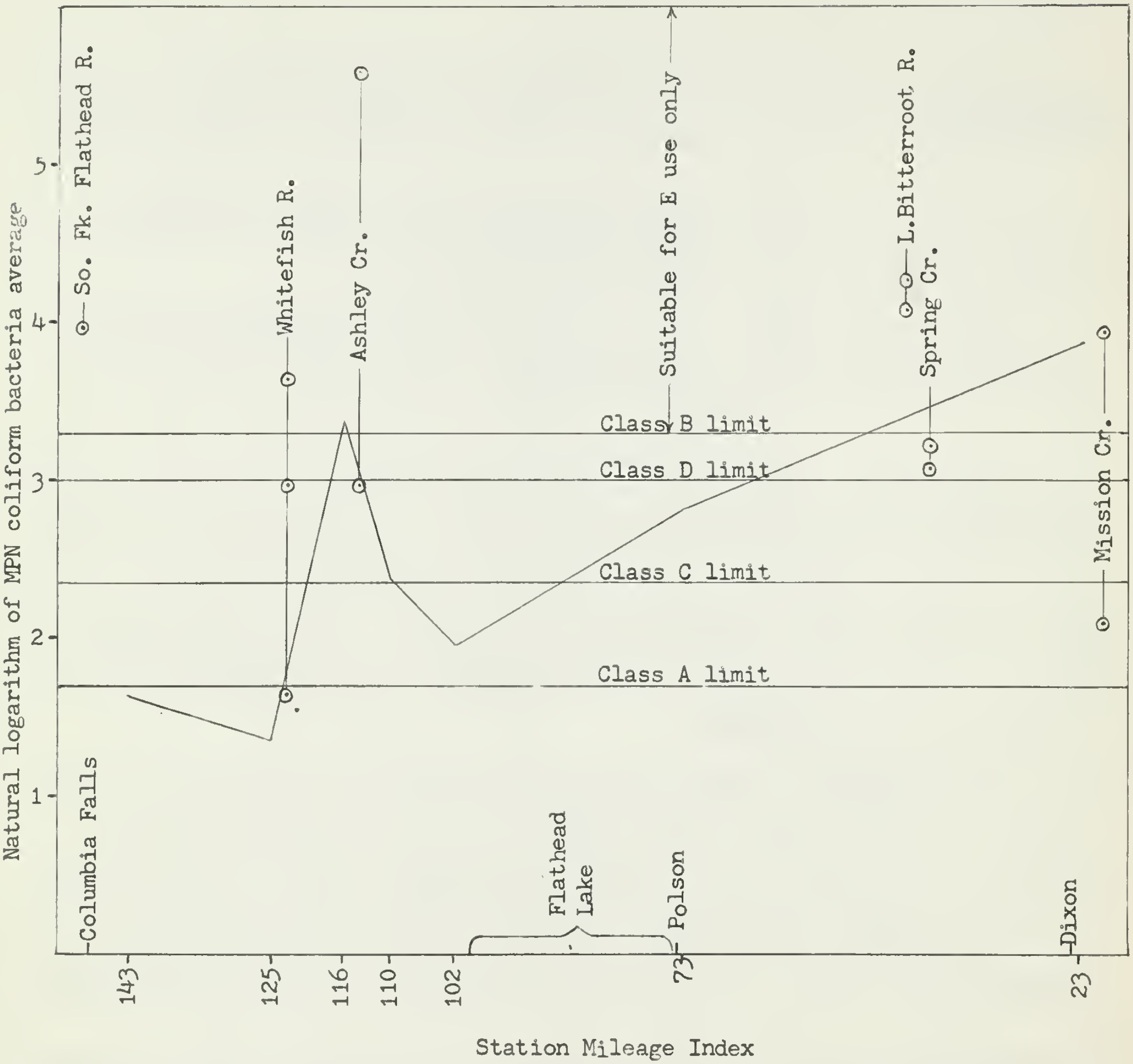
(3) Warm Springs Creek: Warm Springs Creek at the station located above the State Hospital was found to be suitable only for the Class B and E use of water, and at the station below the State Hospital, all uses of the water except agricultrual and industrial are prohibited.

(4) Flint Creek: Based on one coliform sample at four of the five stations established on Flint Creek and two samples at the remaining station, this stream would be suitable for all uses except as a Class A water supply or as a Class C bathing, swimming and recreational stream (Appendix F). Flint Creek from the entrance of the Philipsburg raw sewage to Black Pine Crossing, two miles downstream, is unsuitable for any use other than agricultural and industrial. From this point to Maxville, the stream is suitable for Class B, D and E use. From Maxville to below Hall, the stream is suitable only for Class B and E use, and from this point to its confluence with the Clark Fork River, the water is suitable only for agricultural and industrial use. (Appendix F).

(5) Bitterroot River: Samples of water for coliform analysis were taken at three of the five stations established on the Bitterroot River (Appendix F) and one sample each was taken at the two stations adjacent to Stevensville and at the station immediately above the confluence of the Bitterroot with the Clark Fork River. The coliform index to fecal pollution suggests that the river above Stevensville is suitable for all uses including a Class A water supply, while the river from Stevensville to its confluence with the Clark Fork would be unsafe for use as an unfiltered drinking water supply. All other uses of the river would be permissible, however.

(6) Flathead River: Only a very short section of the Flathead River which was studied was found to be suitable for use as a Class A water supply (Figure 15). This section is located between Columbia Falls and the confluence of the Stillwater River with the Flathead. With the entrance of the Whitefish River into the Flathead via the Stillwater, the coliform index to fecal pollution exceeds the limits established for any use except as a source of agricultural and industrial water. Samples obtained from the river between Kalispell and Polson indicate that the stream would be suitable for Class B use and as a fishing and industrial stream with a ten mile section above Flathead Lake suitable for Class C use (Figure 15). The MPN coliform bacterial content of the stream increases from a point below Polson to the confluence of the Flathead with the Clark Fork near Paradise and at a point approximately twenty miles below Polson the stream is no longer suitable for any use except agricultural or industrial (Figure 15).

Figure 15. Most probable number coliform bacteria averages determined for sampling stations in the Flathead Study Area, 1957.



The South Fork of the Flathead River, the Whitefish River immediately below the discharge of inadequately treated wastes from the community of Whitefish, Ashley Creek below the discharge of inadequately treated wastes from Kalispell, both sampling stations on the Little Bitterroot River and Mission Creek below St. Ignatius are unsafe from the standpoint of coliform index to fecal pollution for any use except as an agricultural or industrial water supply (Appendix F). The Whitefish River above the point of discharge of improperly treated sewage is suitable for all use. Mission Creek above St. Ignatius should be excluded from Class A use only. The Whitefish River two miles above its confluence with the Stillwater, Ashley Creek above the discharge from the Kalispell sewage treatment plant and Spring Creek should be restricted to Classes B and E use only (Figure 15).

(7) Kootenai River: One sample of water for MPN coliform bacterial content determination was collected from each of the sampling stations established in the Kootenai River Drainage Area (Appendix F). The sample obtained in the Kootenai River above the Tobacco River suggests that the river in this area is suitable for all uses. The coliform index to fecal pollution obtained at the station below the confluence of the Tobacco with the Kootenai indicates that the stream is unsafe to use as a source of unfiltered water and is very close to the maximum allowable limits of MPN for use as a Class C or recreational stream. The MPN content of the Kootenai near and below Libby indicates that the stream is suitable only for agricultural or industrial use. The MPN coliform bacterial content of the Tobacco River above Eureka exceeds the limits established for a Class A and C water supply and the collection from below Eureka suggests that the use of the stream should be restricted to agricultural and industrial (Appendix F).

BIOLOGICAL PROCEDURES, RESULTS, AND DISCUSSION

Standard methods of sampling and analysis were employed with the exception of the development of an additional technique for bottom sampling. Bottom materials particularly on the Clark Fork are mainly of rock and rubble size and stream velocities are high, resulting in a definite decrease in efficiency of the Surber, square-foot bottom sampler (1937). With the cooperation and advice of Mr. Wilson, the four-square-foot technique was designed and tested against the Surber sampler. Results of this comparison will be published separately. In general, the larger sample is qualitatively and quantitatively superior to the square-foot technique with regards the larger and more motile organisms while being inferior with regards the numbers of the smaller flora and fauna taken. In no case were organisms taken with the Surber sampler that were not collected by the four-square-foot technique. Equipment employed in the four-square-foot method consists of a square metal frame measuring two feet on each side and a three by four foot Needham hand screen (Needham and Needham, 1955) constructed of common window screen (approximately 14 meshes per inch) and one inch dowelling for handles. The four-square-foot frame is embedded in the bottom and the hand screen held downstream from the frame while the bottom strata is aggitated with the feet, dislodging bottom dwelling organisms which are then swept against the screen by the current. By this method faster and deeper water areas which prohibited the use of the Surber sampler can be sampled.

In general one square-foot sample and two, four-square-foot samples were taken at each collection station. Flora and fauna collected (Appendix G) were sorted at least to Order in the field and tabulated on data collection forms. Surber samples were sorted in a white enamel pan and four-square-foot samples were "picked" while lying the hand screen on white oilcloth to retain those organisms which pass during the screen during sorting.

In most cases, stations for sampling were chosen from riffle areas in contrast to pools or "flat water runs", however; this procedure could not always be followed, especially in the larger streams such as the Kootenai and Flathead Rivers. In these rivers, shore-side samples were taken where the stream velocity was near maximum.

Flora and fauna collected were preserved in 70 percent alcohol and stored for future reference.

A note of explanation concerning the use of stream flora and fauna as biological indicators of pollution is in order here. Various groups of aquatic vertebrates and invertebrates are generally represented in any bottom collection, (Appendix C). Under "clean-water" stream conditions more species of organisms are present and generally fewer individuals of any one species. Under conditions of gross organic pollution the number of different species present decreases drastically and generally an increase in individuals of certain kinds is apparent. In addition, and most important certain organisms are adversely affected by pollutants; others are very tolerant; and still others are faculative, i.e. they can exist to a degree under both clean and polluted water conditions. Further in a well-balanced community of benthic (bottom dwelling) organisms, taxonomic groups of animals and plants belonging to each of the sensitive, tolerant, and faculative divisions are normally present. As the pollution load increases, the sensitive organisms disappear and the faculative-tolerant groups tend to predominate and under conditions of gross pollution, the more tolerant flora and fauna is present.

Many types of analyses and presentation of biological data have been used in the past by biologists working in the field of pollution control and abatement ranging from the mere presence of tolerant forms of flora and fauna in the bottom samples to a very elaborate analysis of the entire benethic community, sometimes based on bioassays of certain individual organisms collected. Today it is generally agreed that the entire community should be analysed.

For the purpose of this preliminary report and for reasons of demand and expediency, a very simple method of analysis is used, based on the number of sensitive organisms present in the collections as related to the total number of organisms taken.

Among the invertebrate benthos, it is universally agreed that the Plecoptera (stoneflies, such as the "salmon fly") Ephemeroptera (mayflies), and Trichoptera (caddisflies or "rockworms") are very intolerant to pollution. Familiarity with the data leads the writer to place the few species of Odonatea (dragon flies) and aquatic Lepidoptera (butterflies) collected, in the sensitive group. Also among the bottom dwelling fishes Cottus spp. (sculpins) have been found to be very intolerant to even light loads of pollution.

The remaining orders of invertebrates and species of fishes exhibit varying degrees of tolerance to pollution and it is among this group classed as faculative and tolerant that the biologist expects the greatest amount of criticism concerning the type of analyses presented here.

Fish present in this group belong to the family Cyprinidae (minnows) and Catostomidae (suckers) and include the Columbia River or peamouth chub (Mylocheilus caurinum, also called locally the "peanose"), the long-nosed dace (Rhinichthys cataractae), the red-side shiner (Gila balteatus, formally Richardsonius balteatus), the squaw fish (Ptycocheilus oregonese), the two suckers, the long-nose and pigmy long-nose (Catostomus and C.c. pocatello) and the large-scale sucker (C. macrocheilus).

The Orders of aquatic invertebrates included in the tolerant or faculative division are the Pulmonata (snails: mostly the air breathing Physa spp.), Coleoptera (beetles), Diptera (midges, black flies, snipe, crane flies, etc.) and Hemiptera (water striders and water boatman). The occassionally collected species of the Class Turbellaria (Planeria sp.), the Sub-class, Arachnida (parasitic mites on Plecoptera), and the Order Amphipoda (side swimmers), were placed in the tolerant-faculative group, since they were found solely in polluted waters during this survey. The Phylum Annelida (earthworms) was represented in the collections by the highly tolerant oligochaets (aquatic earthworms) Turbifex sp., the less tolerant Lumbriculus sp., and the apparently faculative leech (Order, Hirudinea). A few free-living (non-parasitic) nematods (roundworms) were collected and are placed in the faculative group.

The greatest criticism of this type of analysis is expected with regards the Order Diptera. This large taxonmic group includes sensitive, faculative, and tolerant organisms. However, identification of these species is time consuming, particularly since the taxonomy of at least one family, (Tendipedidae, formerly Chironomidae) has never been thoroughly investigated in Montana. Since the same grouping of sensitive and faculative - tolerant organisms was used for the "clean-water control" stations, the error of misplacement of fauna in groups is constant and will have equal effect on the results.

With regards the comparison of conditions in the main stem of the Clark Fork River with its clean-water tributaries, 90 percent fiducial limits of the mean (Table 4) were computed for the percent sensitive organisms taken in the bottom samples.

Table 4. Ninety percent confidence interval for the mean ($\bar{X}$) of percent sensitive bottom organisms in the samples from the "Control Stations" in the Clark Fork Study Area, 1957.

Station	Location	X	X^2
445-2.0	Little Blackfoot River	67	4489
418-2.0	Flint Creek	73	5329
382-2.0	Rock Creek	86	7396
365-2.0	Blackfoot River	74	5476
351-1.0	Bitterroot River	72	5184
271-3.0	St. Regis River	79	6241
Totals		451	34115
$\bar{X}$		75	

$$s = \sqrt{\frac{\Sigma X^2 - \frac{(\Sigma X)^2}{n}}{n-1}} = \sqrt{\frac{215}{5}} = 6.6$$

$$L_{1 \& 2} = \bar{X} \pm t_{.10\,(n-1)}\, s_{\bar{x}} =$$

$$75 \pm 2.015\,(6.6) = 62 \text{ and } 88$$

This essentially gives a statistical range within which the percentage of sensitive organisms could be expected to fall under clean-water conditions 90 percent of the time.

DISCUSSION

For the purpose of discussion, the study area is broken into the following sub-sections: (1) Clark Fork River (Silver Bow Creek) from its origin at the confluence of Yankee Doodle and Blacktail (Bell) Creeks to, and including, the new Anaconda Company settling ponds immediately east of Warms Springs, Montana (hereafter referred to as Warm Springs settling pond), (2) Clark Fork River from Warm Springs, to the Idaho border, (3) Warm Springs Creek, (4) Flint Creek, (5) Bitterroot River, (6) Flathead River, including the South Fork of the Flathead, (7) Whitefish River, Ashley Creek, Little Bitterroot River, Spring Creek and Mission Creek, and (8) Kootenai River.

(1) Clark Fork River (Silver Bow Creek) from Butte to Warm Springs: This section of the river is classified for industrial wastes only since its primary use has been for industrial waste disposal for a period of over thirty years.

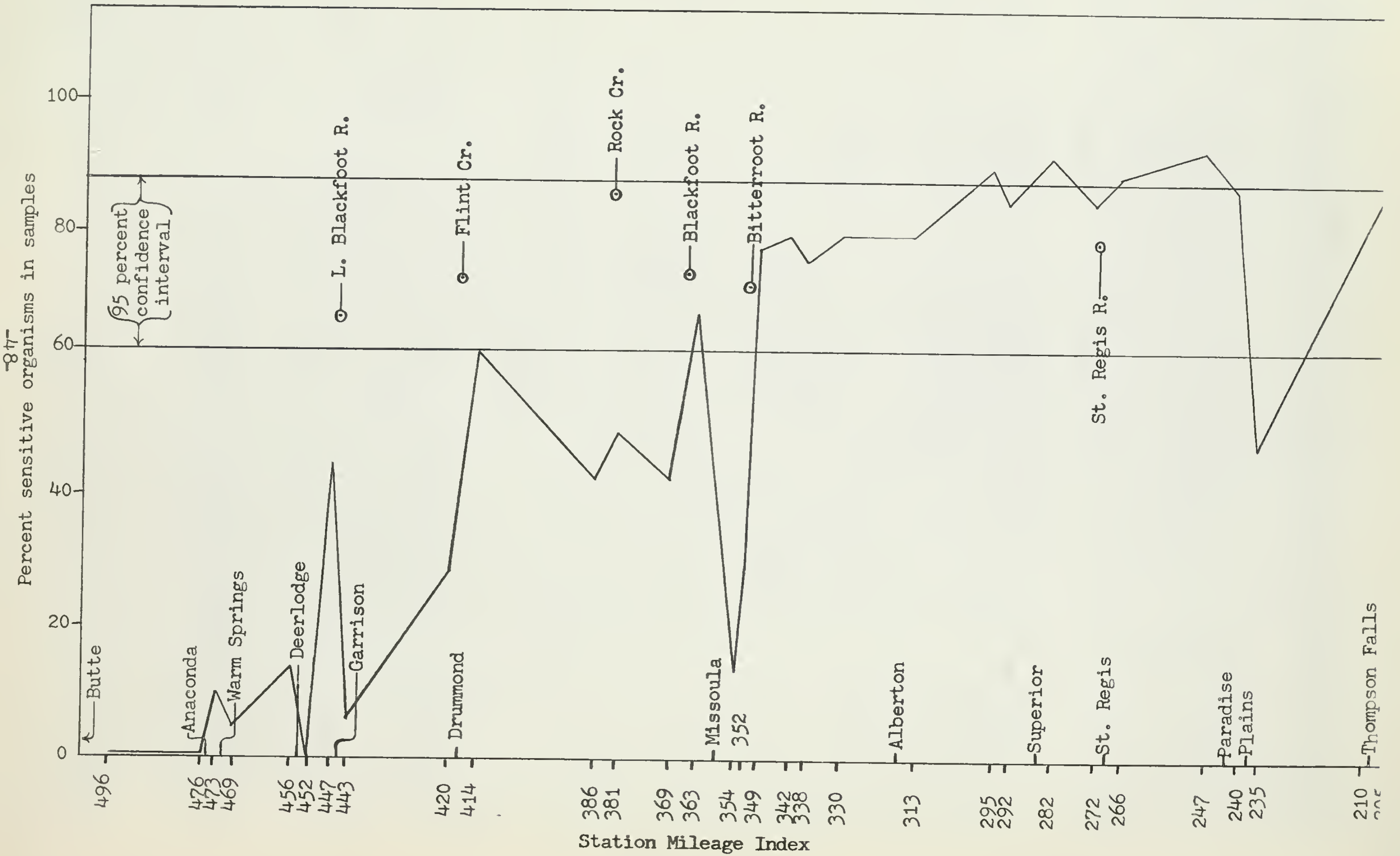
(2) Clark Fork River from Warm Springs to the Montana-Idaho Border: Bottom samples from the Clark Fork above the Anaconda Company settling pond at Warm Springs contained no sensitive macro-invertebrates and only one tolerant form. However, immediately below the settling pond, bottom fauna collections included ten percent organisms, (Figure 16), taken during the second collection period in the latter part of July. This pond was being constructed during the survey period and as the work progressed, the number of benthic organisms increased, (collections during 1958 verify this statement), and a general improvement in stream ecology was noted. Also, by the end of the summer, fisherman were taking brown trout from the Clark Fork in the vicinity of Deer Lodge. This is the only instance known to the writer where game fish were caught in this section of the river, except during a period of mining and milling curtailment at Butte and Anaconda during 1954.

The percentage of sensitive organisms in the collections starts increasing from the low of ten at Station 473 (near Warm Springs), to a peak of 92 at Station 282 (below Superior), (Figure 16) and remains at its highest until Station 235 (below Plains) then recovers again at Station 205 (below Thompson Falls). The extreme variations in percent intolerant organisms between Stations 473 and 342 (about twelve miles downstream from Missoula) can be correlated with the discharge of various wastes (mostly municipal sewage) from communities along the Clark Fork River. The raw sewage from the State Hospital at Warm Springs depresses the percent sensitive curve from ten to five and natural purification affects a recovery to 14 percent at Station 456 above Deer Lodge (Figure 16). The Deer Lodge municipal sewage again decreases the percentage of intolerant benthos to less than 1 at Station 452, from which it recovers to 45 at Station 447 (above Garrison and the confluence of the Clark Fork with the Little Blackfoot River). The control station, 445-2.0, located on the Little Blackfoot River two miles upstream from its confluence with the Clark Fork River, indicates that about 67 percent of the benthos in the streams of this area could be expected to be sensitive organisms under clean-water conditions (Figure 16). Dilution of the Clark Fork by the Little Blackfoot affects a marked recovery approaching clean-water conditions shortly below Drummond and the entrance of Flint Creek.

Raw sewage and other wastes from the Drummond-Bear Mouth Area again depress the percent sensitive curve at a point below the entrance of Rock Creek (Station 386). The Clark Fork River recovers rapidly with the dilution by the clean-water of Rock Creek and the Blackfoot River. At Station 363 (below the entrance of the Blackfoot River and above Missoula) the Clark Fork River first attains a condition which can be described as unpolluted; However, between collection periods 2 and 3 (Appendix H) an excessive amount of silt was discharged from the Montana Power Company Reservoir at Milltown coincident with the placement of a natural gas line across the Blackfoot River near Bonner. This silt load exerted a scouring action on the stream bottom and sides and deposited in the bottom gravel and rubble interstices, causing a definite reduction in the percent sensitive bottom organisms collected during September 1957. The average of percent intolerant benthos would undoubtedly have been somewhat higher at this station with the absence of this temporary silt pollution. (It is interesting to note that the dipertan, Simulidae, was not represented in collections from this section of the Clark Fork, but were very abundant above and below this area. Apparently, blackflies (Simulium sp.) are relatively tolerant of polluted-water conditions).

Much wood waste from the Anaconda Company saw mill at Bonner is evident in the section of the river from Bonner to Missoula. This waste consists largely of bark and sawdust and is added to by the sawmills in Missoula, particularly by the Inter-Mountain Lumber Company.

Figure 16. Percent sensitive organisms in bottom samples taken in the Clark Fork Study Area, 95 percent confidence limits for "control stations", and relative location of communities along the Clark Fork River. 1957.



The percent sensitive curve is again depressed to polluted-water conditions by the raw sewage and industrial wastes discharged from Missoula (Figure 16). Gross pollutional conditions persist from Missoula to the confluence of the Bitterroot with the Clark Fork and this section of the river is essentially an open sewer. The Clark Fork rapidly recovers from this condition by the dilution from the comparatively clean-water of the Bitterroot River. However, this apparent recovery must be viewed with caution, since bacteriologically, the Clark Fork is still a dangerously polluted stream for many miles beyond the confluence of these two rivers (Figure 14).

At various points along the river banks from Station 363 to 342, a 21-mile section from East Missoula to Deep Creek, junked automobile bodies are being used as rip-rapping to minimize erosion during the high water period of the year. Also, several private garbage dumps are located adjacent to the stream. Junk and debris from these dumps is gradually extending into the river. In addition to depressing, the esthetic value of the stream, the debris and auto bodies are a definite hazard to navigation. Survey personnel have experienced, on several occasions, near catastrophic accidents resulting in much damage to boats and motors. Duck hunters, as well as fur trappers, are greatly endangered when power-floating this section of river, particularly during the autumn and winter.

The Clark Fork River from Station 349 (about 2 miles downstream from the confluence of the Bitterroot and Clark Fork River) to Station 240 (about 2 miles below Paradise, Montana) exhibits relatively clean water conditions with minor variations probably resulting from sampling error. The percent sensitive curve falls well within or above the arbitrarily established range denoting a normal, clean water situation (Figure 16). This section of river supports an abundance of plankton, algae and higher aquatic plants and the production of bottom fauna, based on numbers per unit of bottom area, is greatly in excess of that found in other sections of the Clark Fork (Figure 17 and Table 4.) This, of course, is the result of the fertilizing effect by the addition of organic wastes from Missoula and the center of the recovery zone appears to be Station 266 (near St. Regis), (Figure 17).

Creel census reports of the Fish and Game Department reveal that this area of the Clark Fork supports a good to excellent fishery, especially winter fishing for whitefish. During all float trips of the upper portion of this section, an abundance of waterfowl was observed. Nesting mallards (Anas platyrhynchos) were noted and many mallards apparently use the river for a wintering area, since their presence was recorded during mid-winter surveys. Local duck hunters familiar with the river claim it to be one of the better waterfowl hunting areas and many migrating ducks use the river as a resting and feeding grounds. Canada geese (Branta canadensis) were also frequently observed.

Fur bearers are well represented in the area with much evidence of beaver denoted by bank burrows, food caches, and cuttings. Muskrats have been observed occasionally and signs of mink and weasel are common. Trapping appears to be centered in the area between Stations 349 and 338 (Deep Creek to Marcure Ranch). The Clark Fork River from the point of its confluence with the Flathead is a comparatively infertile stream with regards the production of fish food organisms (Figure 17). The number of bottom organisms in the samples range from 6.1 to 13.0 per square foot from Station 240 (near Paradise) to Station 205 (below Thompson Falls) compared to a range of 85.8 to 204.7 from the section between Station 295 (about ten miles upstream from Superior) and Station 266 (below St. Regis) (Table 5). This can be attributed to the high degree of dilution by the very sterile Flathead River and the above mentioned fertilizing phenomenon in the Missoula sewage recovery zone.

Figure 17. Average number of bottom organisms per square foot taken from the Clark Fork Study Area, 1957.

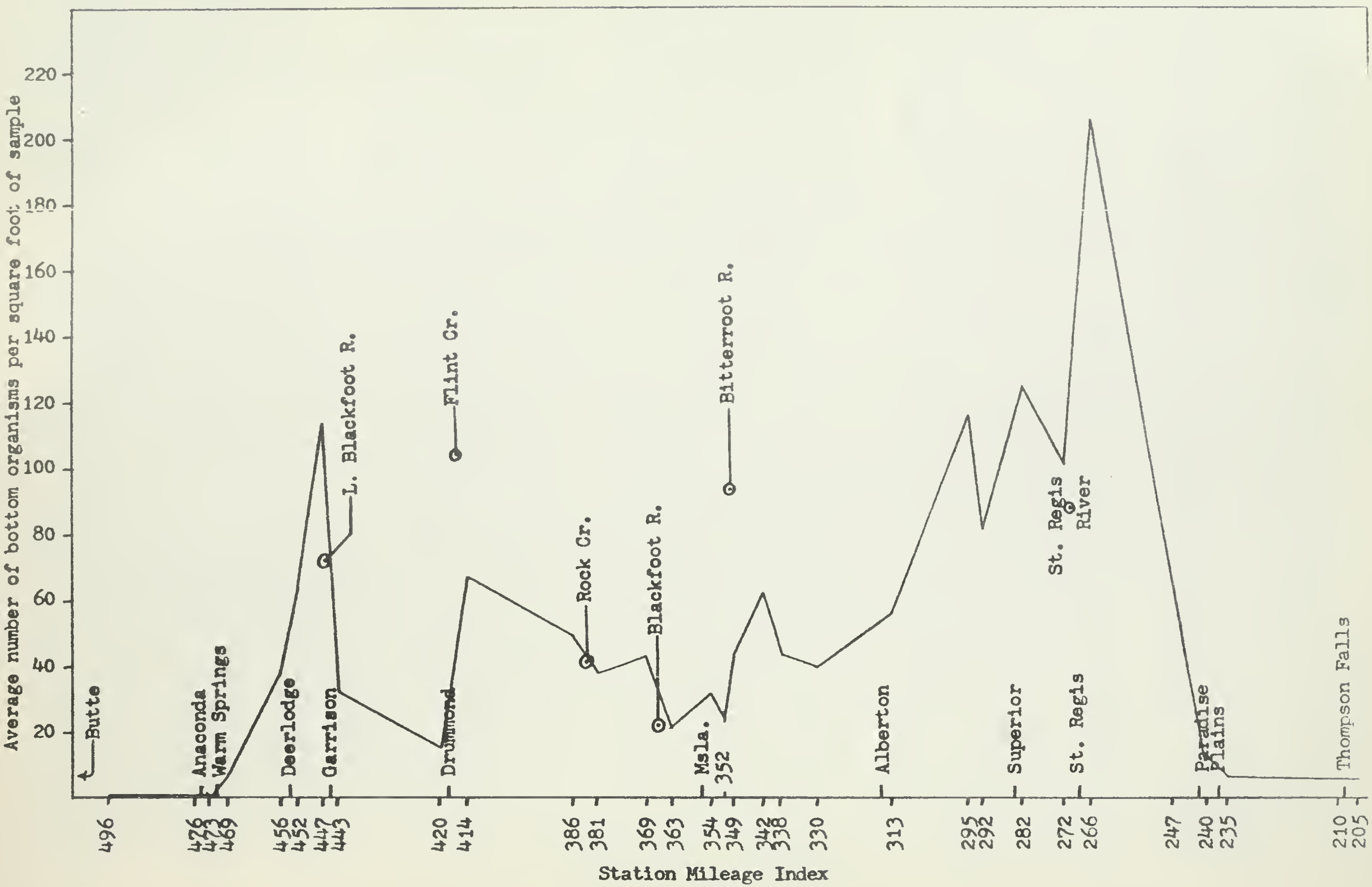


Table 5. Total number of organisms collected, total and percent sensitive organisms in samples, total number of Surber- and Four-square-foot samples collected, total area of bottom sampled, and average number of organisms per square foot of bottom sampled, from sampling stations in the Clark Fork Study Area during the summer of 1957.

Station mileage index	Total	Total sen.	Percent sen.	Total Surber samples taken	Total 4-sq.ft. samples taken	Total sq.ft.of bottom sampled	Ave. No. of organisms per sq. ft.
496	0	0	0	3	1	7	0
476	1	0	0	3	1	7	0.1
473	10	1	10	1	2	9	1.1
472-4.0	710	212	30	2	2	10	71.0
472-0.5	605	3	0.5		2	8	75.6
469	84	4	5		3	12	7.0
456	536	75	14	2	3	14	38.3
452	643	10	0.2	2	2	10	64.3
447	1148	522	45	2	2	10	114.8
445-2.0[1]	1008	671	67	2	3	14	72.0
443	293	17	6	1	2	9	32.6
420	218	64	29	2	3	14	15.6
418-2.0[1]	1452	1058	73	2	3	14	103.7
414	1147	709	62	1	4	17	67.5
386	829	356	43	1	4	17	48.8
382-2.0[1]	744	638	86	2	4	18	41.3
381	684	341	50	2	4	18	38.0
369	1162	497	43	3	6	27	43.0
365-2.0[1]	673	499	74	2	7	30	22.4
363	672	458	68	2	7	30	22.4
354	1061	169	16	1	8	33	32.2
352	794	232	29	1	8	33	24.1
351-1.0[1]	1677	1206	72	2	4	18	93.2
349	1286	1009	78	2	7	30	42.9
342	1871	1523	81	2	7	30	62.4
338	1324	1013	76	2	7	30	44.1
330	1184	942	80	2	7	30	39.5
313	1687	1348	80	2	7	30	56.2
295	3474	3113	90	2	7	30	115.8
292	1458	1240	85	2	4	18	81.0
282	2247	2068	92	2	4	18	124.8
272	1812	1533	85	2	4	18	100.7
271-3.0[1]	438	348	79	1	1	5	87.6
266	3696	3301	89	2	4	18	205.3
247	1112	1032	93	2	4	18	61.8
240	221	192	87	1	4	17	13.0
235	126	60	48	2	4	18	7.0
210			(impossible to obtain bottom samples)				
205	106	91	86	1	4	17	6.2

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[1] "Control stations" located on the Little Blackfoot River, Flint Creek, Rock Creek, Blackfoot River, Bitterroot River, and the St. Regis River

The Clark Fork apparently recovers between Plains and Thompson Falls; however, some raw sewage is discharged to the river from the community of Thompson Falls. Normally, this would cause a depression of the percent sensitive curve, however, this did not occur, (Figure 16). A power dam located at Thompson Falls creates a reservoir adjacent to the community. The light load of sewage from Thompson Falls is discharged into the reservoir. This procedure essentially consitutes lagoon treatment of the wastes accounting for the high numbers of intolerant organisms in the river directly below the Thompson Falls Dam. Again however, this apparent clean water situation should be viewed with caution since the coliform index to fecal pollution exceeds the recommended limits established for the safe use of the stream as a Class A, B, C, and D source of water (Figure 14).

Before concluding the discussion of this section of the river, it is best to point out that the construction of the Noxon Rapids Dam downstream from Thompson Falls will radically alter the ecology of the Clark Fork in this area. Data presented and discussed here will be incomparable with data collected after the river between Thompson Falls and Noxon attains reservoir status. Change from lentic to lotic conditions necessitates a different approach to analyses of biological observations and future survey information must be evaluated accordingly.

(3) Warm Springs Creek: Station 472-4.0 on Warm Springs Creek above the Warm Springs State Hospital was established as a control station in the original experimental design of this study. However, results of the investigation indicate that this station is located in a polluted water zone which has depressed the percent sensitive organisms in the sample to about 30, greatly below conditions which are expected in a clean water stream (Table 5). Station 472-0.5, which is above the Clark Fork River on Warm Springs Creek and below the sewage outfall of the State Hospital reflects gross pollutional conditions, with only one-half of one percent sensitive organisms being represented in the bottom samples. (Authors Note: The 1958 summer survey team reported conditions in Warm Springs Creek below the Hospital in 1958 greatly improved over 1957.

(4) Flint Creek: Six sampling stations were established on Flint Creek (Table 6) which drains Georgetown Lake and flows through Flint Creek Valley past the communities of Philipsburg, Maxville, Hall and New Chicago and enters the Clark Fork about two miles upstream from Drummond, Montana. A clean water control station (418-26) was established above the entrance of the Philipsburg raw sewage and mill wastes and indicate that about 78 percent of the bottom sample includes clean water or sensitive organisms. Station 418-25 is located below the outfall of mill wastes and above the raw sewage from the community of Philipsburg and the percent sensitive organisms is depressed only to 47 percent, however, directly downstream from this station, Station 418-24 which is below the raw sewage outfall, the percent sensitive organisms declined to 27. The stream rapidly recovers from a point about 2 miles downstream from Philipsburg to its confluence with the Clark Fork and bottom samples indicate a clean water situation two miles upstream from the Clark Fork, (Table 17). The practice of discharging mill wastes to natural streams and its resulting adverse affect upon such streams is well represented by Flint Creek. The bottom materials are closely cemented together by mill tailings and this results in a reduction in the productivity of fish food organisms since only the smaller forms are able to exist under these conditions. This is further evidenced by the presence of the larger bottom organisms in the Maxville Canyon area of the stream. The high velocity of the stream in this area does not permit the

deposition of mill tailings and the larger bottom organisms are able to find proper habitat in the Canyon section of stream.

The lower reaches of this stream reflect the improper useage of irrigation waters which is **prevalent** throughout the State of Montana today. During late summer, irrigation waste water is returned with its accompanying load of silt, and discharged to Flint Creek. The practice of excessive flood irrigation without the use of the corrugation principle and proper diking results in a waste of water diverted for irrigation and exerts irrepairable damage to lands by removing topsoil and leaching of soil nutrients.

Table 6. Total number of bottom organisms collected, total and percent sensitive organisms in samples, total number of Surber- and Four -square foot samples taken, total area of bottom sampled, and average number of organisms per square foot of bottom sampled, from sampling stations in the Flint Creek- and Bitterroot River Sub-basin Study Areas during 1957.

Station Mileage Index	Total	Total Sen.	Percent Sen.	Total Surber Samples Taken	Total 4-sq.ft. Samples Taken	Total sq.ft.of Bottom Sampled	Ave.No. of organisms per sq.ft.
			FLINT CREEK				
418-26	555	434	78		1	4	138.8
418-25	304	142	47	1	2	9	33.8
418-24	852	228	27	1	1	5	170.4
418-22	550	316	57	1	2	9	61.1
418-13	754	494	66	1	2	9	83.8
418-2.0	1452	1058	73	2	3	14	103.7
			BITTERROOT RIVER				
351-46	513	374	73	1	2	9	57.0
351-40	709	607	86	1	2	9	78.8
351-27	2926	2189	75	1	4	17	172.1
351-24	1780	1084	61	2	4	18	98.9
351-1.0	1677	1206	72	2	4	18	93.2

(5) Bitterroot River: Four sampling stations were established in a forty-six mile section of the Bitterroot River from Hamilton, Montana to the mouth of the stream near Missoula (Table 6). In addition, the "control station" at 351-1.0, upstream from the confluence of the Bitterroot and the Clark Fork, is included in this discussion.

Composition of bottom fauna indicates that no organic pollution reaches the river from Hamilton. A general decrease from 86 percent sensitive organisms in the samples at the below Hamilton station to 61 percent at the below Stevensville station suggests that some form of organic pollution is introduced into the Bitterroot near or from Stevensville.

The Bitterroot River has been nearly dewatered by irrigation in the past and to preserve the sport fishery in the lower section of this stream, the Fish and Game Department recently purchased water from the Montana Water Conservation Board. This water is delivered to the Clark Fork upon request by the Fishery Division during the late summer period of low flows. Possibly this water will exert an additional benefit through dilution of the pollution load in the Clark Fork downstream from its confluence with the Bitterroot.

(6) Flathead River: As mentioned before, bottom sampling methods in the Flathead River are restricted mostly to shore-side samples creating unavoidable sampling error. In some cases, such as stations 244-149-3.1 (South Fork Flathead below Hungry Horse Dam), 244-116 (Flathead above Ashley Creek), and the Ashley Creek stations (244-114-15 and 9.0), the sample size is considered two small for accuracy (Table 7), however, it is felt that the percent sensitive curve (Figure 18) does indicate the general effect of pollution upon the Flathead River and the results of bottom fauna analysis is supported by MPN coliform organism content determinations (Figure 15).

The bottom fauna collections and MPN analysis indicate little, if any, untreated pollutant being discharged to the Flathead River above the entrance of the Stillwater River. The Stillwater River receives the municipal sewage from Whitefish, Montana, via the Whitefish River which joins the Stillwater about 2 miles above its confluence with the Flathead. This pollutional load depresses the percent sensitive curve to 24 (Table 7). Although this percentage of intolerant benthos in the sample may be somewhat lower than the percentage actually existing at Station 244-116 as indicated by the high proportion of sensitive organisms from the station 2 miles above the Flathead in the Stillwater, MPN coliform organism content indicates that the Flathead is badly polluted by Whitefish sewage.

The inadequately-treated sewage from Kalispell discharged to the Flathead via Ashley Creek allows no recovery from the polluted conditions resulting from the Whitefish sewage discharge and the percentage of intolerant benthos in the samples is low (27 to 38) throughout the remaining length of the Flathead River above its confluence with the Clark Fork River near Paradise (Figure 18).

The various municipal and industrial wastes from the community of Polson exert an adverse effect upon the Flathead below Kerr Dam. The silt pollution introduced into the Flathead by the Little Bitterroot River and the general morphometry of the stream, allows but little recovery to clean-water conditions (Figure 18).

The results of MPN determinations (Figure 15) confirm the indications of fecal pollution suggested by bottom sampling throughout the length of the Flathead from Kalispell to its confluence with the Clark Fork.

(7) Whitefish River, Ashley Creek, Little Bitterroot River, Spring Creek and Mission Creek: Three sampling stations were established on the Whitefish River. Collections were taken from these stations, but once during the study period. (Appendices F and G). Again, it is felt that the conclusions drawn, at least from the biological data alone, should be viewed with caution and that additional sampling should be conducted. However, results of MPN coliform organism analyses (Appendix F) and results of chloride analyses (Appendix C) support the conclusion that raw sewage from the community of Whitefish is discharged to the river.

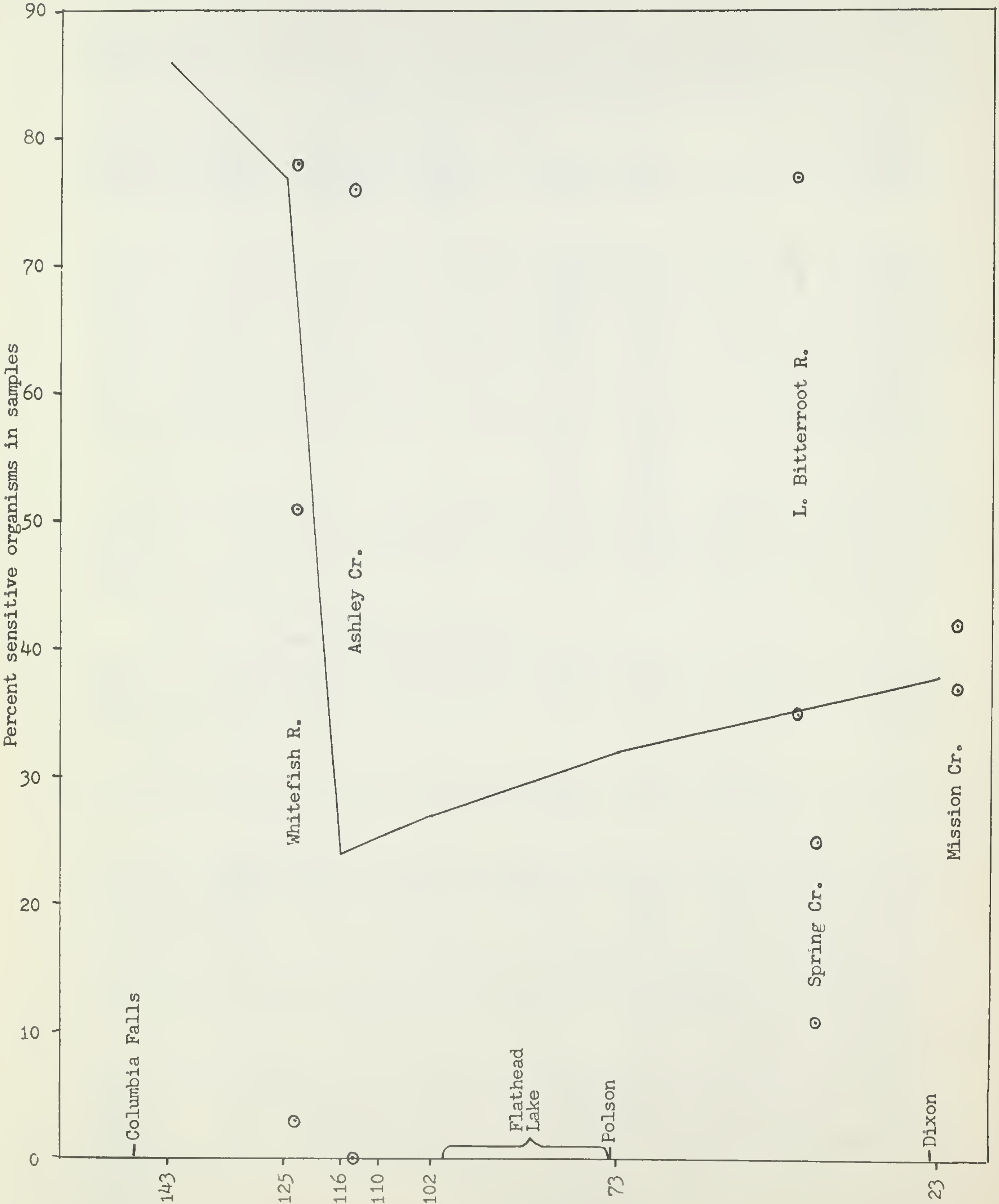
The percentage of intolerant bottom fauna in the samples is depressed to three (from 51) at the below-Whitefish station from which it recovers to 78 at the above-Flathead River station, nine miles downstream (Table 7). Most probable number coliform organisms increases from 43 at the above Whitefish station to 4300 at the below Whitefish station and remains high (930) at the above Flathead station. Also the quantity of chlorides increases from 0 to 4 and 6 ppm at each of the stations, respectively.

Table 7 . Total number of bottom organisms collected, total and percent sensitive organisms in samples, total number of Surber- and Four-square-foot samples taken, total area of bottom sampled, and average number of organisms per square foot of bottom, from sampling stations in the Flathead Sub-basin Study Area during 1957.

Station mileage index	Total	Total sen.	Percent sen.	Total Surber samples taken	Total 4-sq.ft. samples taken	Total sq.ft.of bottom sampled	Ave. No. of organisms per sq. ft.
244-149-3.0*	42	2	5	1		1	42.0
244-143	42	36	86	1	2	9	4.7
244-125	60	46	77	1	2	9	6.7
244-123-2.0-15	311	160	51	1	2	9	34.6
244-123-2.0-11	331	11	3		2	8	41.4
244-123-2.0-2.0	876	682	78	1	2	9	97.3
244-116*	182	43	24	1		1	182.0
244-114-15*	390	296	76	1		1	390.0
244-114-9.0*	235	0	0	2		2	117.5
244-110	(no bottom samples obtained)						
244-102	119	32	27		2	8	14.9
244-73	213	68	32	3	2	11	19.4
244-45-21	783	604	77	5		5	156.6
244-45-19	566	197	35	3		3	188.7
244-42-10-5.0	1328	336	25	1	3	13	102.2
244-42-10-2.0	364	39	11	1	3	13	28.0
244-20-9.0-6.0	744	310	42	2	1	6	124.0
244-20-9.0-3.0	687	254	37	2	1	6	114.5
244-24-2.0	590	419	71	2	4	18	32.8
244-23	272	104	38	2	4	18	15.1

* sample size too small for accuracy

Figure 18. Percent sensitive organisms in bottom samples taken in the Flathead Study Area during 1957.



Although bottom samples alone are considered inadequate in this case, the bacterial and chemical data support the conclusion that the Whitefish River is receiving a non-assimilable load of raw sewage from the community of Whitefish.

Two sampling stations (244-114-15 and -9.0) were established on Ashley Creek above and below the effluent from the Kalispell sewage treatment plant. Only one sample was collected at the above effluent station and two Surber samples were taken at the lower station (Table 7). Although the sample size is small, the results are believed to reflect conditions in this stream. Seventy-six percent of the bottom fauna collected at the above effluent station consisted of organisms intolerant of pollution and no sensitive organisms were collected at the below effluent station. The bulk of the organisms collected at the lower station consisted mainly of the highly tolerant oligochaet, Tubifex sp. In addition, the results of MPN coliform analysis (Appendix F) support the conclusion that raw sewage from the community of Kalispell is inadequately treated.

Two stations were sampled on the Little Bitterroot River above and below Hot Springs, Montana. **Eight square feet** of bottom was sampled during two sampling periods, and the average percentage of sensitive bottom fauna found at the upper station above the discharge of raw sewage from the community of Hot Springs was 77 percent. This figure is depressed to 35 percent at the below Hot Springs station (Table 7).

Two collecting stations were established on Spring Creek above and below Ronan and bottom collections were taken during two sampling periods. The percentage of sensitive organisms found at both the stations was very low suggesting that Spring Creek receives some organic pollution in addition to the raw sewage from the community of Ronan, (Table 7). This situation should be investigated further.

Conditions observed for Mission Creek near St. Ignatius were similar to those found in Spring Creek with the percentage sensitive bottom organisms in the samples being low and with no significant difference being observed between the upper and lower stations above and below the point of discharge of pollutants. Collections from Jocko River above its confluence with the Flathead suggests that the percentage intolerant benthos in the bottom collections should be near 71 percent (Table 7). Again the situation in Mission Creek near St. Ignatius should be investigated further.

(8) Kootenai River: Conditions observed at the six sampling stations established on the Kootenai River drainage (Appendix B) do not seem to follow the normal pattern established for other streams of the study area. The percentage of sensitive organisms vary from 49 at Station 265 which is above any Montana source of pollution to 88 below Libby (Table 8). These findings would indicate that a source of pollution originating somewhere upstream in Canada depresses the percent intolerant benthos to 49 from which it gradually recovers to a high of 88 below Libby. However, it is believed that sampling error is excessive since collections were restricted to shoreside samples. It is further believed that the results of MPN coliform organisms (Appendix F) more nearly reflect the true pollutional picture as it exists and that further and more extensive biological study of the Kootenai River in Montana should be undertaken.

Table 8. Total number of bottom organisms collected, total and percent sensitive organisms in samples, total number of Surber- and Four-square-foot samples taken, total area of bottom sampled, and average number of organisms per square foot of bottom, from sampling stations in the Kootenai River Study Area during 1957.

Station Mileage Index	Total	Total Sen.	Percent Sen.	Total Surber Samples Taken	Total 4 sq.ft. Samples Taken	Total sq.ft.of Bottom Sampled	Ave.No. of organisms per sq. ft.
265	240	118	49		2	8	30.0
262-9.0	585	356	61		2	8	73.1
262-5.0	309	217	70	1	1	5	61.8
257	104	80	77	1	1	5	20.8
204	70	37	53	1	1	5	14.0
198	344	302	88	1	2	9	38.2

(Writer's note: During September, 1958, a plane flight was taken over the length of the Kootenai Drainage in Montana and a highly discolored (yellowish-red) waste discharge was noted in the Kootenai River above Libby. Further investigation is necessary, however, this discharge is believed to be carried by Rainy Creek from the Zonolite (vermiculite) Mill to the Kootenai).

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Appendix A.

REVISED CODES
OF MONTANA
1947
ANNOTATED

"AN ACT TO CREATE A STATE WATER POLLUTION COUNCIL, TO CONTROL, PREVENT AND ABATE POLLUTION OF THE SURFACE AND UNDERGROUND WATERS OF THE STATE OF MONTANA, AND REPEALING CHAPTER 184 OF THE THIRTY FIRST LEGISLATIVE ASSEMBLY, AND REPEALING ALL ACTS OR PARTS OF ACTS IN CONFLICT HEREWITH AND FOR OTHER PURPOSES."

69-1326 . This act shall be known as the Water Pollution Act of the State of Montana.

69-1327 . (a) Statement of Policy. Whereas a comprehensive program of water resource development for municipal and industrial water supply, irrigation, fish and wildlife conservation, and recreation is now in progress in this State, and, whereas pollution of the waters of this State may constitute a menace to public health and welfare, and may adversely affect livestock, wildlife, fish and aquatic life, and may progressively obstruct agricultural, industrial, recreational and other legitimate uses of water, and whereas the problem of water pollution in this State is closely related to the problem of water pollution in adjoining States, it is hereby declared to be public policy of this State to conserve the waters of the State and to protect, maintain, and improve the quality and potability thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for agricultural, industrial, recreational and other legitimate beneficial uses, to provide a comprehensive program in the public interest for the prevention, abatement and control of new or existing water pollution, to provide effective means for the carrying out and enforcement of such program, and to provide for cooperation with agencies of other States and the Federal Government in carrying out these objectives.

(b) It is not the intention of this act that wastes shall be treated to a purer condition than the natural caondition of the receiving stream, provided that any municipal or industrial pollution upstream be not considered as natural.

(c) It is hereby declared to be the intention of this act to effectuate the control of pollution as herein defined only.

69-1328. Definitions. For the purpose of this act, the following words and phrases shall have the meanings ascribed to them in this section:
(a) "Sewage" means the water-carried waste products from the residences, public bulidings, institutions or other buildings, including the excrementitious or other discharge from the bodies of human beings or animals, together with such dround water infiltration and surface water as may be present. The provisions of this act shall not apply to the excrementitious discharges of domestic and farm animals providing human health is not involved.

(b) "Industrial waste" means any liquid, gaseous or solid waste substances resulting from any process of industry, manufacturing, trade or business or from the development of any natural resource together with such sewage as may be present, which may pollute the waters of the state.

(c) "Other wastes" means garbage, municipal refuse, decayed wood, sawdust, shavings, bark, lime, sand, ashes, offal, night soil, oil, tar, chemicals and all other substances which may pollute the waters of the state.

(d) "Contamination" means an impairment of the qualities of the waters of the state by sewage or industrial wastes to a degree which creates a hazard to human health.

(e) "Pollution" as used in this act shall mean the alteration of the physical, chemical or biological properties of any waters of the state which renders said waters harmful or detrimental for their most beneficial uses and over which the authority of the state board of health as vested by Title 69, Chapter 13 of the Revised Codes of Montana, 1947, as herein amended, does not extend, except that no waters not now being used for human consumption as a single public supply system serving more than one hundred (100) persons shall be classified other than for industrial waste use where the same have been primarily and continuously devoted to industrial waste use except for seasonal variations for a period of over thirty (30) years.

Where waters have been classified or standards established pursuant to this act, any discharge which is not in accord with such classification or standards shall be deemed to be pollution.

(f) "Sewerage system" means pipe lines or conduits, pumping stations, and force mains, and all other construction, devices and appliances appurtenant thereto, used for collecting or conducting sewage or industrial waste or other wastes to a point of ultimate disposal.

(g) "Treatment works" means any plant, disposal field, lagoon, dam, pumping station, incinerator, or other words not specifically mentioned herein, installed for the purpose of treating, stabilizing or holding sewage, industrial waste, or other wastes.

(h) "Disposal system" means a system for disposing of sewage, industrial waste or other wastes, and includes sewerage systems and treatment works.

(i) "Waters of the state" means all streams and lakes, including all rivers and lakes bordering on the state, wells, springs, irrigation systems, marshes, watercourses, waterways drainage systems and other bodies of water, surface and underground, natural or artificial, publicly or privately owned. Provided, however, that unless drainage or seepage from artificial, privately owned bodies of water reaches flowing streams of the state in such condition as to pollute such flowing waters, the provisions of this act shall not apply to artificial, privately owned waters; and provided further, the provisions of this act shall not apply to any waters of the state not reasonably suitable for domestic or public water supply for human consumption at the time of passage of this act.

(j) "Person" means the state or any instrumentality thereof, any municipality, political subdivision, institution, public or private corporation, partnership, individual, or other entity.

69-1329. Administration. (a) The state board of health, hereinafter referred to as "the board" shall under the supervision of the council as herein described, have the responsibility for the administration of this act. Subject to the general supervision of said council, the executive officer of the board shall administer the provisions of the act in accordance with said council's rules, regulations, orders, standards of water quality and classifications of the waters of the state. The executive officer of the board may delegate to any employee of the board such of his functions and duties as he deems necessary for the proper and effecient administration of this act, except as provided in (b) below.

(b) There is hereby created a state water pollution council, hereinafter referred to as the "council". The council shall consist of seven (7) members as follows:

The executive officer of the state board of health; the state fish and game warden (director, state fish and game department); the state engineer; and four (4) members to be appointed by the governor as follows: A representative of industry concerned with the disposal of inorganic waste within the state, for an initial term of one (1) year, thereafter for a term of four (4) years; a representative of industry concerned with the disposal of organic waste within the state for an initial term of two (2) years, thereafter for a term of four (4) years; a representative of agriculture within the state for an initial term of (3) years, thereafter for a term of four (4) years; a representative of municipal government within the state for a term of four (4) years. The chairman shall be elected from among their number.

No additional compensation shall be allowed any members of the council for services rendered who are employed by the state government. The four (4) members appointed by the governor to serve on the council shall each be paid in addition to actual travel expenses, ten dollars ($10.00) per day for each day of actual services in the performance of their duties, and all members of the council shall be reimbursed for travel and other necessary expenses incurred in their official duties as members of the council. All expenses of members who are otherwise in the employ of the state government shall be paid from the appropriation to their respective agencies. The expenses and per diem of the members who are appointed by the governor shall be paid from funds available to the state board of health.

The council shall hold at least two (2) regular meetings each calendar year and shall keep a record of its proceedings which shall be open to the public for inspection. Special meetings may be called by the chairman and must be called by him upon receipt of a written request signed by two (2) or more members of the council. Written notice of the time and place for all meetings shall be mailed in advance to the office of each member of the council and the secretary. A majority of the members of the council shall constitute a quorum.

Each member of the council may, by order filed with the secretary of the council, designate a deputy or alternate to perform the duties of the member making the designation. Such persons, if any, designated pursuant to this action, shall have the powers and be subject to the duties and responsibilities of the member designating him.

(c) The secretary of the council shall be a member of the public health engineering staff of the state board of health, designated by the executive officer of the board. The secretary shall keep all records of meetings of and actions taken by the council. He shall keep the council advised as to actions taken by persons in response to recommendations and orders issued under authority of this act and shall perform other duties as determined upon by the council, not inconsistent with rules, regulations, and policies adopted by authority of this act or specific authority otherwise given the council.

69-1330. Powers and duties of the council. The council is herewith authorized and directed:

(a) To study, investigate, or cause to be studied and investigated, and from time to time, determine ways and means of eliminating from the streams and waters of the state, so far as practical, all substances and materials which pollute the same, and to determine methods, so far as practical, of preventing pollution that is detrimental to the public health or the health of animals, fish or aquatic life, or the industrial development of the state, or detrimental to the practical use of waters for recreational purposes, agricultural or industrial purposes, or obnoxious, anuseous or toxic for domestic purposes;

(b) To devise, formulate and adopt rules, regulations and methods of procedure for transmittal to the board for their guidance in the administration of this act;

(c) To develop and adopt a comprehensive program for the prevention, control and abatement of pollution of the waters of the state and from time to time review and modify such program for the guidance of the board;

(d) To recommend and encourage studies, investigations, research, demonstrations relating to water pollution and causes, prevention, control and abatement thereof as are deemed advisable and necessary and to direct the board regarding any actions deemed necessary from the results of such studies, investigations, research and demonstrations in order that the board may discharge its functions under this act;

(e) To formulate the standards of water purity and classification of water according to the most beneficial uses of such water; in formulating such standards and classifications consideration shall be given to the economics of waste treatment and prevention;

(f) To hold hearings necessary for the proper administration of this act; and to receive complaints and make investigations in relation thereto;

(g) To exercise all incidental powers necessary to carry out the purposes of this act;

(h) To utilize, in carrying out its duties, such staff services of the board as the board is able to make available within its budgetary limits.

69-1331. Powers and duties of the board. The board shall have and may exercise the following powers and duties:

(a) To consider actions of this council as set forth in section 69-1330, providing that the board may modify such actions of the council only insofar as is necessary to protect human health;

(b) To accept and administer loans and grants from the federal government and from any other source for carrying out any of its functions;

(c) To issue, modify or revoke orders for the abatement of pollution or to require the adoption of such remedial measure, including the construction of new disposal systems or treatment works or the modifications, extension or alteration of existing systems and works, as it shall be directed by the council;

(d) To examine and approve or disapprove all plans and specifications for the construction and operation of (1) new sewerage systems, disposal systems and treatment works, (2) extensions, modifications of or additions to new or existing sewerage systems, disposal systems or treatment works, (3) extension and modifications of or additions to factories, manufacturing, establishments or business enterprises, the operation of which would cause a substantial increase in waste discharges or otherwise substantially alter the physical, chemical or biological properties of the waters of the state and (4) new outlets for the discharge of sewage, industrial wastes or other wastes into any sewerage system or otherwise into the water of the state subject to the rules and regulations of the council;

(e) To issue, continue in effect, revoke, modify or deny permits to any person for the collection and discharge of sewage and industrial and other wastes under such conditions as the council may prescribe to achieve the purposes of this act;

(f) To advise, consult and cooperate with other agencies of the state and other states and federal government and with affected groups, political subdivisions and industries, in the formulation of such comprehensive program;

(g) To collect and disseminate information relating to water pollution and the prevention, control and abatement thereof;

(h) To conduct as it deems necessary, studies, investigations, research and demonstrations relating to water pollution and the causes, prevention, control and abatement thereof.

69-1332. Pollution unlawful - permits. (a) It shall be unlawful for any person to cause the pollution, as defined in section 69-1328, subsection (e) of this act, of any waters of the state.

(b) It shall be unlawful for any person to construct, install or operate a new sewerage system, disposal system or treatment works, extensions, modifications, or additions to new and existing sewerage systems, disposal systems, or treatment works, estensions, modifications or additions to factories, manufacturing establishments or business enterprises, the operation of which would cause a substantial increase in waste discharges to the waters of the state, or otherwise substantially alter the physical, chemical or biological properties of the waters of the state to make or cause to be made any new outlet for the discharge of sewerage, industrial waste or other wastes into any sewerage system or into the waters of this state without first securing such a permit as the board may by regulations require. The board may require the submission of plans and specifications for approval or disapproval and such other information as it deems relevant in connection with the issuance of such permits.

69-1333. Inspection and entry. The board, through its duly authorized representative shall have the power to enter at reasonable times upon any private or public property for the purpose of inspecting and investigating conditions relating to pollution of ant waters of the state.

69-1334. Classifications and standards. (a) In order to effectuate a comprehensive program for the prevention, abatement and control of pollution in the waters of the state, the council is authorized to group such waters into classes in accordance with their present and future most beneficial uses in the interest of the public and such classification or standards may from time to time be altered or modified. Standards of quality and purity for each such classification of the waters of the state shall be adopted in relation to the most beneficial use and benefit to which the waters are or may in the future be put. Such standards may from time to time be altered or modified.

Before streams are classified or standards established or before such standards are modified or repealed, public hearings by the council shall be held in connection therewith. Notice of public hearing for the consideration, adoption or amendment of the classification of waters and the standards of purity and quality thereof shall specify the water concerning which a classification is sought to be made or for which standards are sought to be adopted and the time, date, and place of such hearing. Such notice is to be published at least once a week for three (3) consecutive weeks in a newspaper of general circulation in the area affected and in addition shall be mailed to such other persons as the council has reason to believe may be affected by such classifications and the settings of such standards.

69-1335. Hearings and review. (a) Any order issued by the council or board shall become final upon thirty (30) days after notice thereof is given to the person affected by such order unless within such thirty (30) day period such person files a notice of application for rehearing with the council. If such notice is filed the council shall accord the applicant a rehearing. A record or summary of the proceedings of such rehearing shall be filed with the council, together with findings of fact made by the council. In any such rehearing, a representative of the council is authorized to administer oaths, examine witnesses and issue notice of hearings and subpoenas requiring the testimony of witnesses and the production of evidence relevant to matter involved in the rehearing. Witnesses shall receive the same fees and mileage as in civil actions. In case of failure to obey a notice of hearing or subpoena issued under this section the district court for the county where the hearing is held shall have jurisdiction upon application of the council or its representatives to issue an order requiring such person to appear and testify or produce evidence as the case may require and any failure to obey such order of the court may be punished by the district court as contempt thereof.

The council shall affirm, modify or reverse such order and notify the appellant of its action. The action of the council shall become final thirty (30) days after notice of such action is served upon the appellant by registered mail or unless within such time an appeal is taken to the district court as herein provided.

An appeal may be taken from any decision of the Council by any person who is or may be adversely affected thereby to the district court of any county wherein any part of such alleged pollution originates or where any other matter or controversy may arise. Within thirty (30) days after receipt of a copy of the order of the Council made on rehearing or after service of notice thereof by registered mail, the appellant or his attorney shall serve a notice of appeal on the Council through its Secretary, provided that during such thirty (30) day period the Court may for good cause shown extend the time for notice of appeal for not exceeding an additional sixty (60) days. The notice of appeal shall refer to the action appealed from and shall specify the ground of appeal. The original notice of appeal with proof of service shall be filed by the appellant or his attorney with the Clerk of the Court within ten (10) days of the service of the notice and thereupon the Court shall have jurisdiction of the appeal.

The appellant and the Council shall in all cases be deemed the original parties to an appeal. Any person affected may become a party by intervention as in a Civil action upon showing cause therefor. The Attorney General shall represent the Council if requested by the Council on all such appeals on behalf of the State, or the Council is empowered at its discretion to appoint special counsel for such proceeding. No bond or deposit for cost shall be required of the State or Council upon any such appeal or upon any subsequent appeal to the supreme court or other court proceedings, pertaining to the matter.

The trial of the matter shall be do nove, and upon such trial the court shall determine whether or not the Council regularly pursued its authority, or whether or not the orders of the Board and the findings of the Council outht to be sustained, or whether or not such orders and findings are reasonable under all of the circumstances of the case.

An appeal may be taken from the decision of the district court to the supreme court of Montana in the same manner as is provided in civil cases. Upon the final determination of such judicial proceedings, the Council shall enter an order in accordance with such determination.

69-1336. Penalties. Any person who violates any final determination or order of the Board or of the Council shall be enjoined from continuing such violation.

69-1337. Compliance. Within thirty (30) days after the date on which order of the Board or of the Council becomes final or after the date judgment affirming such an order is entered, the person or persons as defined herein upon whom the order has been served shall initiate such steps as may be necessary to comply with it. Provided, however, upon good cause shown the Board or the Council shall extend said thirty (30) day period for a reasonable period of time.

69-1338. Injunction. It shall be the duty of the Council to bring action for an injunction against any person or persons violating any final order of the Board or of the Council.

69-1339. State Officers to Cooperate with the State Water Pollution Council. The Council is hereby authorized to require the assistance, cooperation and services of and the use of the records and files in all the departments and institutions of the state, and all state officers and the governing authorities of all state institutions are hereby directed to cooperate with the Council in furthering the purposes of this Act.

69-1340. Repeal. All acts or parts of acts which are inconsistent with the provisions of this Act are hereby repealed. The provisions of this Act are, however, not to be construed to impair or lessen in any manner the existing powers and duties of the State Board of Health, except that Chapter 184 of the Thirty-First Legislative Assembly is hereby repealed.

69-1341. Preservation of Rights. It is the purpose of this Act to provide additional and cumulative remedies to prevent, abate and control the pollution of the waters of the State. Nothing herein contained shall be construed to abridge or alter rights of action or remedies in equity under the common law or statutory law, criminal or civil, nor shall any provisions of this Act or any Act done by virtue thereof, be construed as estopping the state, or any municipality or person as owners of water rights or otherwise in the exercise of their rights in equity or under the common law or statutory law to suppress nuisances or to abate pollution.

Seperability Clause. If any section, subsection, sentence, clause, phrase or words of this Act is for any reason held to be unconstitutional, such decrees shall not affect the validity of any remaining portions of this Act.

Appendix B. Locations and descriptions of sampling stations established during the summer of 1957, on the Clark Fork and Kootenai River Drainage Systems and their Corresponding Columbia River and Tributaries Mileage Indices.

CLARK FORK RIVER DRAINAGE SYSTEM

LOCATION	MILEAGE INDEX	DESCRIPTION
Clark Fork River (Silver Bow Creek) at Silver Bow	496	150 feet upstream from Chicago-Milwaukee-St. Paul & Pacific R. R. crossing on gravel road to community of Silver Bow
Clark Fork (Silver Bow Cr.) above Anaconda Company's new settling basin (on the Clark Fork) near Warm Springs	476	At U.S. Highway 10 S crossing about 2 miles south of Warm Springs
Clark Fork below new settling basin	473	1000 yards southeast of Mont. Fish & Game Department game bird farm.
Warm Springs Creek above Warm Springs and the Clark Fork River	472-4.0	One and one-half miles north-east of the junction of Mont. Highway 48 and U.S. Highway 10 S on 48.
Warm Springs Creek below Warm Springs and above the Clark Fork.	472-0.5	One-quarter mile downstream from Warm Springs State Hospital.
Clark Fork River below Warm Springs	469	Two miles north of Warm Spgs. along U.S. Highway 10S, thence one mile east and 150 feet upstream from bridge crossing
Clark Fork River above Deer Lodge	456	About one mile south of Deer Lodge at bridge crossing Clark Fork on 10 S.
Clark Fork below Deer Lodge	452	About four miles north of Deer Lodge on 10 S.
Clark Fork River above Little Blackfoot River and Garrison	447	Two miles southeast of U.S. Highways 10S-10N junction on 10S.
Little Blackfoot River above the Clark Fork River	445-2.0	One and four tenths miles northeast of 10S-10N junction on Tom Sherlock ranch off 10S.
Clark Fork River below Little Blackfoot River and Garrison	443	One and one-half miles west of Garrison on U.S. Highway 10 about 100 yards downstream from the Silver Star Bar.

Clark Fork River above Drummond and Flint Creek	420	One and nine tenths miles west of Drummond on 10 to third access road (on south side of highway) from city limits sign.
Flint Creek on the McDonald Ranch	418-26	About one and one-half miles west and south of Philipsburg.
Flint Creek above Philipsburg	418-25	Eight-tenths mile west of U.S. highway 10A on farm-to market road to Willow Creek and about 100 yards above bridge.
Flint Creek below Philipsburg	418-24	About 300 yards downstream from Station 418-25 and about 150 yards below Philipsburg sewage outfall.
Flint Creek at Black Pine crossing	418-22	At bridge crossing on road to Black Pine lookout which junction with U.S. 10A is about two miles north of Philipsburg.
Flint Creek near Maxville	418-13	West of Maxville across Northern Pacific Railway and near U.S.G.S. bench marker number C 141 - 1934.
Flint Creek above the Clark Fork River	418-2.0	Two and six-tenths miles south of Drummond along U.S. 10A, thence east seven-tenths mile to large red barn along New Chicago road, thence north four-tenths mile to a point about 100 yards downstream from the confluence of Lower Willow Creek with Flint Creek.
Clark Fork River below Drummond and Flint Creek	414	Three and three-tenths miles west of Drummond on U.S. 10.
Clark Fork River above Rock Creek	386	About 300 yards south of railway station at Bonita
Rock Creek above the Clark Fork River	382-2.0	Two miles south of U. S. 10 on Rock Creek road at first point at which creek can be seen from road.

Clark Fork River below Rock Creek	381	Two and three-tenths miles west on U.S. 10 from Rock Creek road. One and one-tenth miles downstream from confluence of Rock Creek with the Clark Fork and about 200 yards upstream from Albert Rude ranch.
Clark Fork River above the (Big) Blackfoot River	369	Two and four-tenths miles east of junction of Montana Highway 20 and U. S. 10 on the Petersen ranch.
Blackfoot River above the Clark Fork	365-2.0	One and six-tenths miles northeast of 20-10 junction and upstream from Bonner.
Clark Fork River below the Blackfoot River (East Missoula Station)	363	Three and three-tenths miles west of Milltown along U.S. 10 and across road from R. L. Deschamps ranch.
Clark Fork River below Missoula and above the Bitterroot River. (Missoula Sewage Station)	354	About one-half mile downstream from the Daly Meat Company slaughterhouse on the old Mullan Road.
Clark Fork River above the Bitterroot River	352	At the west end of Third Avenue on the O. C. Culver residence.
Bitterroot River above Hamilton	351-46	At the junction of U.S. 93 and the Bitterroot River bridge, three and six tenths miles south of Hamilton about 50 yards upstream from the railway bridge.
Bitterroot River below Hamilton	351-40	Immediately upstream from U.S. 93-Bitterroot River bridge about one and one-half miles north of Hamilton.
Bitterroot River above Stevensville	351-27	On J. E. Riley ranch two miles south of Stevensville.
Bitterroot River below Stevensville	351-24	Below Stevensville-Bitterroot River bridge east of U.S. 93 and about one and one-quarter miles north and west of Stevensville.

Bitterroot River above the Clark Fork River	351-1.0	Above U.S. 93 and railway bridges about one mile south of District Number 2 Fish & Game Headquarters south of Missoula.
Clark Fork River below the Bitterroot River	349	On the H. Jay Cusker ranch off the old Mullan Road, south and west of Missoula.
Clark Fork River at Deep Creek (Deep Creek Station)	342	South and west of Missoula on the old Mullan Road. Turn south at the Primrose Railway Station at W.J. Sullivan mail box. One-quarter mile upstream from bridge crossing river at Deep Creek (Bridge now condemned and blocked).
Clark Fork River at the Marcure Ranch (Marcure Ranch Station)	338	On the Marcure Ranch about two river miles downstream from proposed Waldorf Paper Company pulp mill site.
Clark Fork River at Six Mile (Six-Mile Station)	330	About one and one-half miles south of the Six-Mile Bar and Cafe on U. S. 10.
Clark Fork River below Alberton (Sawmill Gulch Station)	313	Four and six-tenths miles west of Alberton on U.S. 10.
Clark Fork River at Forest Grove (Quartz Ranger Station)	295	Eighteen and six-tenths miles west of Alberton on U.S. 10 and 200 yards upstream from the Forest Grove Campgrounds.
Clark Fork River above Trout Creek and Superior	292	Three-quarter mile downstream from Lozeau on U. S. 10
Clark Fork River below Superior	282	Two miles downstream from Superior and one and nine-tenths miles along the Old St.Regis road and about one-half mile downstream from the Mitchell (or Oakley) ranch. A Conoco Service Station can be seen on U.S.10 opposite this station.
Clark Fork River above St. Regis	272	About seven-tenths mile upstream from the Railway bridge-U.S. 10 overpass east of St. Regis.
Clark Fork River below St. Regis	266	Three miles downstream from St. Regis on the St.Regis-Paradise Ferry road and east of Butler Gulch.

Appendix B, Continued

Clark Fork River above Paradise and the Flathead River	247	One mile upstream from the Clark Fork River bridge crossing of U. S. 10A on the St. Regis-Paradise Ferry road.
South Fork of the Flathead River below Hungry Horse Dam	244-149 3.0	About 100 feet downstream from the U. S. G. S. Guaging Station, one and one-quarter miles downstream from Hungry Horse Dam.
Flathead River below Columbia Falls	244-143	One hundred feet downstream from County bridge on the Henry Rahn residence.
Flathead River above the Stillwater River	244-125	Two miles east of Kalispell along Second Street, Kiwanis Camp road, and Kiwanis Campground, and about one-half mile downstream from County bridge.
Whitefish River below Whitefish Lake and above Whitefish	244-123 2.0-15	About 50 to 75 yards along the rock spillway below Whitefish Lake.
Whitefish River below Whitefish	244-123- 2.0-11	At State Highway 40 crossing of Whitefish River 2.5 miles from Whitefish toward Columbia Falls.
Whitefish River above the Flathead River	244-123- 2.0-2.0	Two and seven-tenths miles north from Dairy Queen in Kalispell, thence eight-tenths mile to Lawrence Diest residence.
Flathead River above Ashley Creek	244-116	Two and seven-tenths miles east from the Four-corners area south of Kalispell along U. S. 93.
Ashley Creek above Kalispell	244-114-15	Two miles west of Kalispell on U.S. 2, thence south about one-tenth mile on the J.H. Dern road to the County bridge.
Ashley Creek below Kalispell	244-114-9.0	Below bridge seven-tenths mile west from the Four corners intersection on U.S. 93, two miles south of the Flathead County Courthouse in Kalispell.
Flathead River below Ashley Creek	244-110	One mile west and one and seven-tenths miles south of Creston. Turn at the S. Mast mail box and continue to river.

Flathead River above Flathead Lake	244-102	Fifty feet downstream from bridge located three and one-half miles north of Bigfork on Montana 35 and one mile west along the road to Somers.
Flathead River below Kerr Dam	244-73	About 350 yards below Kerr Dam on the south side of the river and adjacent to the power substation.
Little Bitterroot River above Hot Springs Creek	244-45-21	One and seven-tenths miles downstream and about 150 yards above the confluence of the Hot Springs road with the Little Bitterroot river along the road to the airport.
Little Bitterroot River below Hot Springs	244-45-19	About one-half mile north of the junction of Montana 28 with Hot Springs road, east about two miles along the road to the airport, thence north about one-quarter mile to bridge crossing river.
Spring Creek above Ronan	244-42-10-5.0	Two tenths mile east of U.S. 93-Round Butte road junction in north Ronan. Station at the first bridge crossing.
Spring Creek below Ronan	244-42-10-2.0	Seven-tenths mile west of Ronan on the Round Butte road from U.S. 93 junction, thence south at the Misco Mills about 2½ miles to the Bob Symington ranch. Station at bridge adjacent to ranch.
Jocko River above the Flathead River	244-24-2.0	About 50 yards upstream from the Jocko River-Indian Agency bridge east of Dixon.
Mission Creek above St. Ignatius	244-20-9.0-6.0	One and one-tenths miles upstream along the Mission Dam road from the town of St. Ignatius.
Mission Creek below St. Ignatius	244-20-9.0-3.0	One and three-tenths miles west of U.S. 93 on a dirt road opposite the Holy Family Hospital on U.S. 93 southwest of St. Ignatius.
Flathead River below Dixon	244-23	About 100 yards downstream from county bridge directly north of Dixon.

Clark Fork River below Paradise	240	Two and two-tenths miles downstream along Swamp Creek access road, south side of river along U. S. 10A, below Paradise.
Clark Fork River below Plains	235	One and nine-tenths miles downstream on the county road along south side of river from Plains.
Clark Fork River above Thompson Falls	210	One and thirty-five hundredths miles upstream along the Cherry Creek road, thence north to the river forth-five hundredths mile to pipeline crossing river.
Clark Fork River below Thompson Falls	205	Two miles downstream from Thompson Falls on U.S. 10A and about 100 yards upstream from bridge.

KOOTENAI RIVER DRAINAGE SYSTEM

Kootenai River above the Tobacco River	265	Three and one-tenths miles north along Ivan Ingram road from Mont. 37 north of the Rexford Ranger Station and from the Tobacco River-Montana 37 crossing.
Tobacco River above Eureka	262-9.0	One-half mile upstream from Eureka adjacent to the W.C. Alby Lumber Mill yard.
Tobacco River below Eureka	262-5.0	Five miles upstream from the Rexford Ranger Station along Montana 37, thence right eight-tenths mile along the Burt Roe road to bridge.
Kootenai River below the Tobacco River	257	About fifty yards downstream from bridge crossing river on Montana 37 one mile south of Rexford.
Kootenai River above Libby	204	One and one-half miles upstream from the Airport Ranger Station north of Libby on the Willy Taylor farm.
Kootenai River below Libby	198	Four miles downstream from Libby along U.S. 2 on the Merton Miller farm.

Appendix C. Chemical water analysis, water temperature, and turbidities conducted by standard field methods at sampling stations from the Clark-Fork-Flathead-Kootenai Study Area, 1957.

Station Number	Date	Water temperature (F^o)	Dissolved oxygen (ppm)	Dis. Oxygen Saturation(%)	pH	Tot. Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$	Chlorides as ppm Cl-	Turbidity as ppm SiO_2
				Clark Fork-Flathead Drainage					
496	7/1	62	0	0	4.7	0[2]	550[2]	0[2]	205
	8/20	66	0	0	4.7	20[2]	inh.[2]	-[2]	340
476	7/1	64	4.9	59	5.7	0[2]	350[2]	16	155
	8/20	64	4.0	49	4.7	26[2]	inh.[2]	8	115
473	7/1	64	8.8	104	7.0	44	750	12	6
	8/20	70	8.0	107	7.2	54[2]	inh.[2]	20	9
472-4.0	7/1	65	8.5	107	8.0	160	570	6	-
	8/20	64	8.6	107	8.0	170	632	6	<7
472-0.5	7/1	64	7.1	88	8.2	180	672	24	-
	8/20	68	7.4	96	8.0	172	824	8	<7
469	7/2	60	7.4	87	6.8	24	-	10	
	8/21	59	8.4	98	7.3	50[2]	inh.[2]	8	13
456	7/2	59	9.4	109	7.6	102	400	10	8
	8/21	58	8.6	98	7.8	144[2]	inh.[2]	10	6
452	7/2	62	11.0	136	8.0	132	-	18	-
	8/21	61	9.0	105	8.0	162	600	12	15
447	7/2	69	10.6	137	7.8	134	650	18	12
	8/21	67	8.4	105	8.2	158	440	6	8
445-2.0	7/2	62	8.5	100	7.8	104	120	14	-
	8/21	67	9.0	117	8.2	140	176	2	<7
443	7/2	67	9.6	115	7.4	130	550	18	8
	8/21	70	8.4	103	8.2	210	304[2]	16	2
420	7/3	66	9.0	105	8.2	140	300	12	-
	8/22	62	8.4	97	8.2	164	424	14	<7
418-26	5/17	44	10.7	105	7.8	60	64	-	10
418-24	5/17	49	10.0	105	7.0	69	82	-	28
418-22	5/17	55	9.6	108	7.8	77	84	-	20
418-13	5/17	54	9.0	100	8.2	80	88	-	28

[2] interfering ions

[1] at temp. and altitude

Station Number	Date	Water temperature (F^0)	Dissolved oxygen (ppm)	Dis. Oxygen Saturation(%)	pH	Tot. Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$	Chlorides as ppm Cl-	Turbidity as ppm SiO_2
Clark Fork-Flathead Drainage									
418-2.0	7/3	59	9.5	109	8.2	176	196	10	-
	8/22	58	9.2	104	8.2	210	304	10	<7
414	7/3	62	9.4	110	8.2	156	296	20	-
	8/20	68	9.6	120	8.6	190	400	14	<7
386	7/4	58	8.1	88	7.6	146	280	16	-
	8/22	70	12.0	153	8.8	162	389	12	<7
382-2.0	7/3	57	8.8	96	7.4	62	32	6	-
	8/23	58	8.4	93	7.8	76	84	0	<7
381	7/4	56	8.3	90	7.8	102	172	10	-
	8/23	61	10.4	118	8.7	116	240	8	<7
369	6/26	56	8.5	91	7.8	114	158	8	10
	7/26	57	9.0	97	7.6	114	228	8	<7
	9/3	56	10.4	111	8.1	120	260	16	<7
365-2.0	6/25	59	9.4	103	8.2	100	104	4	10
	7/26	63	8.2	95	8.2	116	128	4	<7
	9/3	56	9.4	100	8.2	120	138	4	<7
363	6/26	57	8.3	90	8.0	112	128	6	15
	7/26	67	8.4	102	8.2	116	160	8	<7
	9/3	59	9.2	102	8.2	120	228	12	14
354	6/26	58	8.1	89	8.0	108	118	16	-
	7/31	67	9.0	109	8.4	100	148	10	<7
	9/5	68	9.2	117	8.2	124	192	8	<7
352	6/26	58	8.6	93	7.9	110	126	26	-
	7/29	65	8.4	99	8.0	128	160	4	<7
	9/6	54	7.6	78	7.8	124	192	8	<7
351-46	8/19	58	9.2	103	7.5	46	58	4	<7
351-40	8/19	58	10.8	120	8.1	64	64	4	<7
351-27	8/16	61	8.0	91	7.6	50	64	0	<7
	9/9	56	9.0	97	7.8	88	76	10	<7
351-24	8/16	65	10.4	123	7.8	130	104	10	<7
	9/9	57	10.6	115	8.0	104	96	6	<7
351-1.0	8/19	68	9.6	117	8.2	96	94	4	<7
	9/6	64	9.8	115	8.0	94	92	8	<7
349	6/27	57	8.5	92	7.8	96	116	24	-
	7/29	70	9.2	115	8.2	120	142	14	<7
	9/6	58	9.6	104	8.1	116	174	8	<7

Station Number	Date	Water temperature (F°)	Dissolved oxygen (ppm)	Dis. Oxygen Saturation(%)	pH	Tot. Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$	Chlorides as ppm Cl-	Turbidity as ppm SiO_2
			Clark Fork-Flathead Drainage						
342	6/27	58	8.3	89	7.8	80	72	4	-
	7/30	65	8.4	96	8.0	108	128	8	<7
	9/5	61	9.6	98	8.1	116	160	6	<7
338	6/28	58	8.8	95	7.6	76	78	12	-
	7/30	65	8.8	102	8.0	110	132	8	<7
	9/5	61	10.0	112	8.2	116	160	4	<7
330	6/27	61	9.4	105	7.8	84	84	10	-
	7/31	67	8.4	100	8.0	120	138	6	<7
	9/5	57	10.2	109	8.0	120	154	6	<7
313	6/28	59	8.5	93	7.4	72	88	16	13
	9/4	58	9.2	99	8.1	120	150	18	<7
295	6/28	60	8.5	94	7.6	76	76	18	15
	9/4	62	10.0	113	8.2	124	152	16	<7
292	7/9	63	8.8	101	7.9	84	88	6	-
	8/26	63	9.6	111	8.8	120	140	12	10
282	7/9	67	9.2	110	7.2	74	84	6	-
	8/25	63	11.0	127	8.8	132	142	16	8
272	7/9	64	8.5	98	7.2	80	88	6	-
	8/25	63	10.8	122	8.8	126	140	8	<7
271-3.0	7/10	56	9.0	89	7.3	40	42	4	-
266	7/10	64	8.1	93	7.8	76	96	6	-
	8/27	58	9.0	96	8.2	108	186	4	<7
247	7/11	64	7.6	86	7.9	94	116	6	-
	8/15	65	9.6	110	8.2	124	140	4	<7
244-149-3.0	7/25	67	8.8	107	6.8	64	68	0	<7
244-143	7/25	67	9.6	117	7.8	76	80	6	<7
244-125	7/24	60	9.4	107	8.0	76	86	12	<7
244-123-2.0-15	7/24	70	9.0	114	8.0	70	76	0	<7
244-123-2.0-11	7/24	69	8.4	105	8.0	74	80	4	<7
244-123-2.0-2.0	7/24	67	8.8	107	8.0	80	94	6	12
244-116	7/23	59	9.8	110	7.8	78	92	6	13
244-114-15	7/23	70	9.4	118	8.0	132	140	12	<7

Station Number	Date	Water temperature (F°)	Dissolved oxygen (ppm)	Dis. Oxygen Saturation(%)	pH	Tot.Alkalinity as ppm $CaCO_3$	Hardness as ppm $CaCO_3$	Chlorides as ppm Cl-	Turbidity as ppm SiO_2
			Clark Fork-Flathead Drainage						
244-114-9.0	7/23	74	2.2	29	6.8	208	220	10	19
244-110	7/23	64	8.6	100	7.6	80	92	12	28
244-102	7/23	63	9.4	108	7.8	80	92	10	<7
244-73	7/17	68	8.1	100	8.0	74	76	12	<7
	8/28	67	9.8	119	8.2	78	88	4	<7
244-45-21	7/16	68	6.3	76	7.8	112	78	14	300
	8/27	61	9.6	108	8.2	102	94	8	75
244-45-19	7/16	70	6.1	75	7.8	106	76	20	300
	8/27	61	9.0	102	8.1	104	88	24	55
244-42-10-5.0	7/17	56	11.0	117	8.8	118	62	4	<7
	8/28	53	13.0	133	8.9	126	124	6	<7
244-42-10-2.0	7/17	60	9.7	108	8.2	110	62	4	<7
	8/28	55	11.4	119	8.2	132	128	2	<7
244-24-2.0	7/22	64	9.6	109	8.2	130	156	14	<7
	8/29	58	9.8	105	8.2	136	152	8	<7
244-23	7/22	67	7.2	85	8.0	110	114	0	11
	8/29	60	9.2	101	8.2	118	124	20	<7
244-20-9.0-6.0	7/22	58	9.4	101	7.6	74	84	8	<7
	8/29	54	9.4	97	7.8	82	94	6	<7
244-20-9.0-3.0	7/22	64	9.4	112	8.0	108	112	10	<7
	8/29	52	9.8	89	7.8	108	170	6	<7
240	7/11	68	7.7	93	8.0	84	88	16	-
	8/15	68	8.0	97	8.2	120	106	8	<7
235	7/11	68	8.5	102	8.0	80	88	10	-
	8/15	67	8.6	101	8.2	120	112	10	<7
210	7/12	68	7.9	95	8.0	76	84	8	-
205	7/12	68	7.2	87	8.2	78	88	10	-
	8/15	66	8.8	98	8.2	110	136	8	<7

Station Number	Date	Water temperature (F^{o})	Dissolved oxygen (ppm)	Dis.Oxygen Saturation(%)	pH	Tot.Alkalinity as ppm CaCO$_3$	Hardness as ppm CaCO$_3$	Chlorides as ppm Cl-	Turbidity as ppm SiO$_2$
Kootenai Drainage									
265	8/13	59	9.8	105	8.2	116	176	10	<7
262-9.0	8/13	49	9.4	91	8.1	134	146	0	<7
262-5.0	8/13	53	10.0	101	8.1	144	152	6	<7
257	8/13	59	9.8	103	8.2	118	176	12	<7
204	8/14	57	9.6	102	8.2	116	156	2	<7
198	8/14	59	10.0	106	8.2	116	148	10	<7

Appendix D. Chemical water analyses conducted by the State Board of Health Chemistry Laboratory on water samples from the Clark Fork-Flathead-Kootenai Study Area, 1957.

Station	Date	Sulfates ppm as SO_4	Logarithm of SO_4 Conc.	Phosphates ppm	Iron ppm	Lead ppm	Zinc ppm	Copper ppm	Arsenic ppm
Clark Fork-Flathead Drainage									
496	7/1				140	0.04	2.7		0.04
	8/20	1,180	3.072	0	205	0	3.35	11.2	0
476	7/1				21	0.01	1.12		0.03
	8/20				38	0	3.66	4.2	0
473	7/1				0.28	0	0.4		Tr.
	8/20	880	2.944	0	1.2	0	0.36	0.01	0
472-4.0	8/20	370	2.568	0					
472-0.5	8/20	440	2.643	0					
469	8/21	875	2.942	0					
456	7/2				0.44	0	0.06		0.008
	8/21	360	2.556	0	0.2	0	0.04	0	0
452	8/21	305	2.484	0.1					
447	7/2				0.42	0	0.06		0.008
	8/21	280	2.447	0.1	0.4	0	0	0	0
445-2.0	8/21	25	1.398	0.1					
443	7/2				0.33	0	0		0
	8/21	215	2.332	0.2	0.15	0	0	0	0.025
420	8/22	215	2.332	0.1					
418-2.0	8/22	70	1.845	0.1					
414	8/20	200	2.301	0.2					
386	8/22	210	2.307	0.1					
382-2.0	8/23	5	0.699	0					
381	8/23	115	2.061	0					
369	9/3	135	2.130	0					
365-2.0	9/3	5	0.699	0					
363	9/3	85	1.929	0					
352	9/6	65	1.813	0					

Station	Date	Sulfates ppm as SO_4	Logarithum of SO_4 Conc.	Phosphates ppm	Iron ppm	Lead ppm	Zinc ppm	Copper ppm	Arsenic ppm
Clark Fork-Flathead Drainage									
351-46	8/19	0	-	0	-	-	-	-	-
351-40	8/19	5	0.699	0.1					
351-27	8/16	0	-	0					
	9/9	5	0.699	0					
351-24	8/16	10	1.000	0.1					
	9/9	5	0.699	0					
351-1.0	8/19	0	-	0					
349	9/6	55	1.740	0					
342	9/5	45	1.653	0					
338	9/5	40	1.602	0					
330	9/5	40	1.602	0					
313	9/4	35	1.544	0					
295	9/4	35	1.544	0					
292	8/26	30	1.477	0.1					
282	8/25	30	1.477	0					
272	8/25	25	1.398	0					
266	8/27	25	1.398	0					
247	8/15	25	1.398	0					
244-73	8/28	5	0.699	0					
244-45-21	8/27	35	1.544	0.24					
244-45-19	8/27	25	1.398	0.14					
244-42-10-5.0	8/28	0	-	0					
244-42-10-2.0	8/28	0	-	0.2					
244-20-9.0-6.0	8/29	0	-	0					
244-20-9.0-3.0	8/29	0	-	0					
244-24-2.0	8/29	5	0.699	0					

Station	Date	Sulfates ppm as SO_4	Logarithum of SO_4 Conc.	Phosphates ppm	Iron ppm	Lead ppm	Zinc ppm	Copper ppm	Arsenic ppm
			Clark Fork-Flathead Drainage						
244-23	8/29	5	0.699	0	-	-	-	-	-
240	8/15	10	1.000	0					
235	8/15	10	1.000	0					
210	8/15	10	1.00	0					
205	8/15	15	1.176	0					

STATE OF MONTANA WATER POLLUTION COUNCIL

STREAM CRITERIA FOR WASTE DISCHARGES

WATER QUALITY OBJECTIVES AND MINIMUM TREATMENT REQUIREMENTS FOR MONTANA SURFACE AND UNDERGROUND WATERS

WATER QUALITY WATER USES	ORGANISMS OF THE COLIFORM GROUP	FLOATING, SUSPENDED SETTLEABLE SOLIDS AND SLUDGE DEPOSITS	TASTE OR ODOR PRODUCING SUBSTANCES	DISSOLVED OXYGEN	pH	TOXIC, COLORED, OR OTHER DELETERIOUS SUBSTANCES	PHENOLIC COMPOUNDS	OIL	HIGH TEMPERATURE WASTES	MINIMUM TREATMENT REQUIREMENTS FOR DOMESTIC SEWAGE
(A) WATER SUPPLY, DRINKING, CULINARY, AND FOOD PROCESSING. Without treatment other than simple disinfection and removal of naturally present impurities.	Most probable number (MPN) coliform bacterial content of a representative number of samples should average less than 50 per 100 ml. in any month.	None attributable to sewage, industrial wastes, or other wastes which, after reasonable dilution and mixture with receiving waters, interfere with the best use of these waters for the purpose indicated.	None attributable to sewage, industrial wastes or other wastes.	Greater than five (5) parts per million, except for underground waters.	Hydrogen ion concentration expressed as pH should be maintained between 6.5 and 8.5	None alone or in combination with other substances or wastes in sufficient amounts or of such nature as to make receiving water unsafe or unsuitable for use indicated (U. S. P. H. S. Stds)	Less than five (5) parts per billion	None	Not in sufficient quantities alone or in combination with other wastes to interfere with the use indicated.	Primary treatment and effective disinfection except in special cases as determined by the State Board of Health. Sewage lagoon treatment will meet this requirement.
(B) WATER SUPPLY, DRINKING, CULINARY, AND FOOD PROCESSING. With treatment equal to coagulation, sedimentation, filtration, disinfection, and any additional treatment necessary for removing naturally present impurities	MPN coliform bacterial content of a representative number of samples should average less than 2000 per 100 ml. and should not exceed this number in more than 20 percent of samples examined in any month where associated with domestic sewage.	(Same as for use "A" above).	None attributable to sewage, industrial wastes or other wastes which, after reasonable dilution and mixture, will increase the threshold odor number above eight (8).	Same as for use "A" above.	Same as for use "A" above.	Same as for use "A" above.	Same as for use "A" above.	None detectable	Same as for use "A" above.	Same as for use "A" above.
(C) BATHING, SWIMMING, AND RECREATION. Note: When waters are used for recreational purposes such as fishing and boating, exclusive of bathing and swimming, the number "1000" may be substituted for "240" in statement of coliform objectives.	MPN coliform bacterial content of a representative number of samples should average less than 240 per 100 ml. and should not exceed this number in more than 20 percent of samples examined in any month where associated with domestic sewage.	Same as for use "A" above.	None attributable to sewage, industrial wastes or other wastes which, after reasonable dilution and mixture, will interfere with the best use of these waters for the purpose indicated.	Greater than five (5) parts per million.	Same as for use "A" above.	Same as for use "A" above.	Less than twenty five (25) parts per billion or none in sufficient amounts as to impart a residual taste to recreational or commercial fish or other aquatic forms	Same as for use "B" above.	Same as for use "A" above.	Same as for use "A" above.
(D) GROWTH AND PROPAGATION OF FISH AND OTHER AQUATIC LIFE. Including waterfowl, furbearers, and other aquatic and semi-aquatic life.	See note under "C" above.	Same as for use "A" above.	None attributable to sewage, industrial wastes or other wastes which will interfere with the palatability or propagation of recreational or commercial fish or other edible aquatic forms.	Same as for use "C" above.	Same as for use "A" above.	None alone or in combination with other substances or wastes in sufficient amount or of such character as to make receiving waters unsafe or unsuitable for use indicated.	Same as for use "C" above.	Same as for use "B" above	Not in sufficient quantity as to increase the temperature of the receiving water beyond that optimum for the normal aquatic life of the specific water.	Primary treatment and effective disinfection. Sewage lagoon treatment will meet this requirement.
(E) AGRICULTURAL AND INDUSTRIAL WATER SUPPLY Without treatment except for the removal of natural impurities to meet special quality requirements other than those classified under "A" above. Note: Permissible limits for total concentration percent sodium, boron, chlorides, and sulphates to receive further study, suggested value for percent sodium is less than 40. Percent sodium computed as the ratio of sodium to total cations expressed in equivalent weights. Calculated from the formula: Na X 100 + Na + K + Ca + Mg when Na, Ca, K, and Mg are expressed in equivalents.		Same as for use "A" above	None attributable to sewage, industrial wastes or other wastes which will adversely effect the marketability of agricultural or industrial produce.	Greater than three (3) parts per million.	Hydrogen ion concentration expressed as pH should be maintained between 6.0 and 9.5	Same as for use "A" above.	None in sufficient quantity as to make receiving water unsuitable for use indicated.	Same as for use "B" above	Same as for use "A" above.	Same as for use "D" above.

Water Quality Objectives of a watercourse will apply at the point of discharge of a waste except in special cases where the sampling points will be determined by the Montana Water Pollution Council.

Determinations in the above table will be in accordance with "Standard Methods for the Examination of Water, Sewage and Industrial Wastes".

Adopted tentatively Feb. 28, 1956
Revised April, 1958
Reviewed Sept. 2, 1958

Appendix F. Most probable number (MPN) coliform organisms determined for streams of the Clark Fork-Flathead-Kootenai Study Area, 1957.

Station Number	Date	Time	MPN	MPN Range	MPN Average	Log. of MPN Ave.
Clark Fork-Flathead Drainage						
476	7/2 8/21	1300 1300	7.3 430	7.3 - 430	219	2.340
473	7/2 8/21	1300 1300	3.6 62	3.6 - 62	33	1.518
472-4.0	7/2 8/21	1300 1330	430 2,400	430 - 2,400	1,415	3.151
472-0.5	7/2 8/21	---- 1330	110,000 2,400,000	$1.1 \times 10^5 - 2.4 \times 10^6$	1.255×10^6	6.099
469	7/2	----	93		93	1.968
456	7/2 8/21	1400 1400	910 1,400	910 - 2,400	1655	3.219
452	7/2 8/21	1400 1400	2,400 9,300	2400 - 9,300	5,858	3.767
447	7/2 8/21	1430 1430	240 230	230 - 240	235	2.371
	7/2 8/21	1500 1500	150 2,400	150 - 2,400	1,275	3.106
420	7/2 8/22	1600 1000	23 4,300	23 - 4,300	2,162	3.335
418-26	6/6	----	430		430	2.633
418-24	6/6	----	1,500,000		1.5×10^6	6.176
418-22	6/6	----	750		750	2.875
418-13	6/6	----	1,500		1,500	3.176
418-2.0	7/2 8/22	1330 1200	4300 2,400	2400 - 4,300	3,350	3.525
414	7/2 8/22	1340 1400	4,300 2,400	2400 - 4,300	3,350	3.525
386	8/22	1630	140		140	2.146
369	4/18 6/27 9/9	---- 1200 1010	240 73 1,200	73 - 1.200	504	2.703

Appendix F, Continued

Clark Fork-Flathead Drainage

Station Number	Date	Time	MPN	MPN Range	MPN Average	Log. of MPN Ave.
365-2.0	4/18	----	240	43 - 240	142	2.152
	9/9	1000	43			
363	3/9	1700	150	43 - 930	539	2.732
	4/18	----	43			
	6/27	1130	930			
	8/2	0930	430			
	9/9	1025	750			
	10/8	1015	930			
352	3/9	1530	43,000	$4.3 \times 10^4 - 2.9 \times 10^5$	1.56×10^5	5.193
	4/18	----	43,000			
	6/27	1100	240,000			
	8/2	0900	110,000			
	9/9	1140	290,000			
	10/8	1000	210,000			
352	4/18	----	4,300	930 - 4,300	2,543	3.405
	6/27	0830	2,400			
	9/9	1115	930			
351-27	9/9	1300	43		43	1.633
351-24	9/9	1600	150		150	2.176
351-1.0	9/9	1550	93		93	1.968
349	4/18	----	430	430 - 4,300	2,158	3.334
	6/27	1045	2,400			
	8/2	0830	4,300			
	9/9	1205	1,500			
342	3/9	1200	2,400	2,300 - 15,000	5,531	3.743
	4/18	----	2,400			
	6/27	1015	2,400			
	8/1	1730	2,300			
	8/1	1930	4,300			
	8/1	2130	2,300			
	8/1	2330	4,300			
	8/2	0130	4,300			
	8/2	0330	9,300			
	8/2	0530	9,300			
	8/2	0730	15,000			
	9/9	1240	4,300			
	10/8	0935	9,300			
338	3/9	1300	2,400	2,300 - 4,300	3,350	3.525
	9/9	1300	4,300			

Station Number	Date	Time	MPN	MPN Range	MPN Average	Log. of MPN Ave.
			Clark Fork-Flathead Drainage			
330	4/18	----	4,300	2,300 - 4,300	3,120	3.494
	6/27	0945	2,400			
	8/2	0700	2,300			
	9/9	1345	2,300			
	10/8	0915	4,300			
313	3/9	1400	23	23 - 2,400	1,266	3.102
	6/27	0930	2,400			
	8/2	0730	2,400			
	9/9	1415	240			
295	9/9	1440	230		230	2.362
282	7/15	1350	2,300	75 - 2,300	823	2.915
	8/12	1200	93			
	8/26	1400	75			
	7/15	1230	2,300	23 - 2,300	854	2.931
	8/12	1300	240			
	8/27	0900	23			
247	7/12	1105	75	9.1 - 93	59	1.771
	8/12	1900	93			
	8/27	1030	9.1			
244-149-3.0	7/25	1200	9,300		9,300	3.968
244-143	7/25	1400	43		43	1.633
244-125	7/24	2100	23		23	1.362
244-123-2.0-15	7/24	1700	43		43	1.633
244-123-2.0-11	7/25	1000	4,300		4,300	3.633
244-123-2.0-2.0	7/24	1100	930		930	2.968
244-116	7/24	1425	2,400		2,400	3.380
244-114-15	7/24	0800	930		930	2.968
244-114-9.0	7/24	1450	390,000		3.9 X 10^5	5.591
244-110	7/24	1340	240		240	2.380
244-102	7/24	1400	93		93	1.968

Appendix F, Continued

Station Number	Date	Time	MPN	MPN Range	MPN Average	Log. of MPN Ave.
Clark Fork-Flathead Drainage						
244-73	7/17 8/28	---- 1100	430 930	430 - 930	680	2.832
244-45 21	7/18 8.27	0840 1400	15,000 9,300	9,300 - 15,000	12,150	4.085
244-45 19	7/18 8/27	0945 1700	15,000 23,000	15,000 - 23,000	19,000	4.279
244-42-10-5.0	7/17 8/28	---- 1700	2,300 93	93 - 2,300	1,197	3.078
244-23	7/18 8/29	1115 1100	15,000 150	150 - 15,000	7,575	3.879
244-20-9.0-6.0	7/18 8/29	1220 0900	240 75	75 - 240	158	2.199
244-20-9.0-3.0	7/18 8/29	1208 1000	15,000 2,300	2,300 - 15,000	8,650	3.937
240	7/15 8/12 8/27	1040 0715 1040	20 23 23	20 - 23	22	1.342
235	7/15 8/27	1000 1040	9.1 23	9.1 - 23	16	1.204
210	7/15 8/27	0930 1100	4,300 93	93 - 4,300	2,196	3.342
205	7/15 8/27	0815 1115	93 460	93 - 460	276	2.441
Kootenai Drainage						
265	8/6	1900	23		23	1.362
262-9.0	8/6	1730	430		430	2.633
262-5.0	8/6	1800	15,000		15,000	4.176
257	8/6	1940	230		230	2.362
204	8/7	1000	9,300		9,300	3.968
198	8/7	0930	93,000		93,000	4.968

Appendix G. Date of Collections, Type and Number of Bottom Samples Taken, and Total Number of Organisms Collected From Stations Sampled in the Clark Fork-Flathead-Kootenai Study Area During 1957.

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
			Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected[2]									
496	7/1	1 S										
	7/1	1 F										
	8/20	1 S										
476	7/1	1 S										
	7/1	1 F										
	8/20	2 S										
473	7/1	1 F										
	8/20	1 S								3		
	8/20	1 F				1				6		
472-4.0	7/1	1 S				18		18	5	41		
	7/1	1 F				32	17	94	29	40		
	8/20	1 S				1	4	17	2	218		
	8/20	1 F	1	1			5	16	27	136		
472-0.5	7/1	1 F			*		1	2	2	*		
	8/20	1 F		100	*					200*		
469	7/2	1 F										
	8/21	2 F					1	3	80			
456	7/2	1 S							1	51		1
	7/2	1 F						2	1	93		
	8/21	1 S						8		134		4
	8/21	2 F					9	56		176		

*exceeding 75-100 per square foot

[1] S = Surber square foot method; F = Four-square-foot Technique

[2] Pul. = Pulmonata; Olig. = Oligochaeta; Eph. = Ephemeroptera; Plec. = Plecoptera; Tric. = Trichoptera; Col. = Coleoptera; Dip. = Diptera; Hem. = Hemiptera

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
452	7/2	1 S								*		
	8/21	1 S								57+*		
	8/21	2 F					1	15		270+*		
447	7/2	1 S						*		*		
	8/21	1 S						*		*		
	8/21	2 F						322		319		1
445-2.0	7/2	1 S				156	9	58	1	100		1
	7/2	1 F				232	17	68	5	145		
	8/21	1 S				7	4	31		20		
	8/21	1 F				20	23	46	2	63		
443	7/2	1 F							1	*		
	8/21	1 S					3	10		39		4
	8/21	1 F					2	2		132		
420	7/3	1 S							5	12		
	7/3	1 F							1	14		
	8/22	1 S						30	1	5		5
	8/22	2 F					2	32	39	71		1
418-26	8/10	1 F	1		7	106	32	195+*	7	107		
418-25	8/10	1 S			58	13	28	8		13		
	8/10	2 F			12	47	1	45	11	67		1
418-24	8/10	1 S			143	41	19	30	32	97		
	8/10	1 F			147	51	37	50	69	136		
418-22	8/10	1 S			14	61	14	66	7	73		
	8/10	2 F			32	77	11	87	17	91		

*exceeding 75-100 per square foot

[3] includes Arachnoidea, Nematoda, Turbellaria, Amphipoda, and Odonata

Appendix G, Continued

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected								
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
418-13	8/10	1 S				23	69	42	30	61		2
	8/10	2 F				79	172	95	28	141		12
418-2.0	7/3	1 S				161	3	146	1	164		
	7/3	2 F				251	14	2*	2	95		
	8/22	1 S				6	13	*	2	2		2
	8/22	1 F					64	*	27	81		18
414	7/3	1 S				1			2	22		1
	7/3	2 F				6	4	13	5	58		
	8/22	2 F				204	156	325	15	135+*		
386	7/4	1 S				4		200	2	20		
	7/4	2 F				17		60	21	176		
	8/22	2 F				22	9	44	4	250		3
382-2.0	7/3	1 S				40	21	29	1	9		
	7/3	2 F				77	64	15	6	14		
	8/23	1 S				7	18	8	1	4		
	8/23	2 F				110	181	68		71		
381	7/4	1 S				89	5	20	2	9		2
	7/4	2 F				35	8	10		42		
	8/23	1 S				10	16	8		*		
	8/23	2 F				18	84	38	13	177		
369	6/26	1 S	2			5	14	2		56		
	6/26	2 F				6	21	1	8	109		5
	7/26	1 S				17	35	13	8	18		
	7/26	2 F				19	30	16	82	68		
	9/3	1 S				3	17	4	4	31		
	9/3	2 F		2		22	195	77	26	246		

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* exceeding 75-100 per square foot

[3] includes Arachnoidea, Turbellaria, Nematoda, and Odonata

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
365-2.0	6/25	3 F	2			138	8	82	19	39		
	7/26	1 S					9	12	1			
	7/26	2 F				12	37	73		44		
	9/3	1 S				17	16	5	1	3		
	9/3	2 F				8	20	61	2	64		
363	6/26	3 F	1			31	32	20	1	33		
	7/26	1 S				5	15	9	1	8		
	7/26	2 F				9	74	59	5	28		
	9/3	1 S					7	1		2		
	9/3	2 F				2	119	75	5	130		
354	6/26	3 F			88	39	10	17	3	51		
	7/31	1 S			61	4	5			13		
	7/31	2 F	4	13	78+*	10	16	1	3	44		
	9/5	3 F	1	84	355	3	53	11	5	89		
352	6/26	3 F	1		15	24	19	8	14	25		1
	7/29	1 S				14	11	4	6	12	1	1
	7/29	2 F			94	16	12	5	3	38		
	9/6	3 F	5	8	175	60	56	3	90	68	5	
351-46	8/19	1 S				34	57	134	12	30		8
	8/19	2 F	2			54	36	58	9	79		
351-40	8/19	1 S				8	4	6	2	5		
	8/19	2 F	3			273	134	181	18	75		
351-27	8/16	2 F	5			616	299	130	36	257		
	9/9	1 S				208	79	22	29	160		
	9/9	2 F	2			281	378	175	27	222		

* exceeding 75-100 per square foot

[3] includes Arachnoidea and Turbellaria

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
351-24	8/16	1 S				47	22	7	4	29		
	8/16	2 F				138	166	203	24	248		
	9/9	1 S				48	24	28	9	114		
	9/9	2 F				242	77	82	15	253		
351-1.0	8/19	1 S				24	26	94		14		
	8/19	2 F	1			121	132	123		53		
	9/6	1 S				1	6	8	1	9		
	9/6	2 F	1			57	187	427	8	384		
349	6/27	3 F	1	1	14	63	69	168	35	73		
	7/29	1 S				2	31	58	3	15		
	7/29	2 F	1		1	28	137	119	7	36		
	9/6	1 S				2	18	29	2	17	2	
	9/6	2 F		1		6	111	168	5	62	1	
342	6/27	3 F				44	43	14	26	37		
	7/30	1 S					19	26	1	6		
	7/30	2 F	3		1	33	132	297	4	36		
	9/5	1 S	1				51	53	4	43		2
	9/5	2 F	3				408	403	14	167		
338	6/28	3 F	8		1	84	48	42	30	44	171	1
	7/30	1 S				10	51	5+2*	1			
	7/30	2 F				53	35	107+3*	2	53		
	9/5	1 S					10	1	6	9		
	9/5	2 F			3	3	12	41	26	157		10
330	6/27	3 F				27	65	143	10	47	120	1
	7/31	1 S				10	10	19		18		1
	7/31	2 F	4			18	128	121	5	36		
	9/5	1 S	2			3	3	5	4	32		1
	9/5	2 F	1			3	87	300	6	69		5

* exceeding 75-100 per square foot

[3] includes Arachnoidea, Turbellaria, Amphipoda, and Odonata

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
			Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
313	6/28	3 F	1				19	19	1	12		
	8/1	1 S				8	6	18	1	39		
	8/1	2 F				11	13	229+*		44		
	9/4	1 S				14	8	114	4	68		
	9/4	2 F	1			7	159	623	5	163		
295	6/28	3 F	1			50	30	86	3	26	1	2
	8/1	1 S				2	8	*		8		
	8/1	2 F	3	1			35	2*		19		1
	9/4	1 S				1	5	7	2	3		
	9/4	2 F				1	85	2495	9	287		5
292	7/9	1 S	6			9	3	70	1	26		1
	7/9	2 F	24		5	5	35	373	3	21		
	8/26	1 S				1	9	22	3	32	1	
	8/26	2 F	2		10	4	14	695	6	77		
282	7/9	1 S						175		29		
	7/9	2 F	50	1		19	14	565	7	59		
	8/26	1 S						96	1	11		
	8/26	2 F		1		12	22	1164	6	14		1
272	7/9	1 S	1			2	5	45	24	23		3
	7/9	2 F	2		5	5	7	125	1	10		
	8/26	1 S			5	3	8	156	1	41		
	8/26	2 F	2		1	17	24	1135	4	129	27	1
271-3.0	7/10	1 S				112	63	28	1	46		25
	7/10	1 F				19+*	3	23	1	17		
266	7/10	1 S	1			14	4	154	1	258		
	7/10	2 F				18	33	434	10	87		
	8/27	1 S					5	120		7		
	8/27	2 F	1	4		6	202	2311		26		

* exceeding 75-100 per square foot

[3] includes Arachnoidea and Odonata

Appendix G, Continued

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected								
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
247	7/11	1 S					2			4		
	7/11	2 F	1			7	13	186+2*	1	5		
	8/15	1 S				10	6	99+*	2	34		
	8/15	2 F	2	8		12	239	58+*	2	21		
244-149 3.0	7/25	1 F				1	1			40		
244-143	7/25	1 S				2						
	7/25	2 F				16	4	12	1	5		
244-125	7/24	1 S				1	1	1				
	7/24	2 F			2	21	17	5	3	9		
244-123-2.0-15	7/24	1 S				3	5	17		68		1
	7/24	2 F	70	4	27	51	11	3		11		40
244-123-2.0-11	7/25	2 F		22	25	3	3		2	25+2*		51
244-123-2.0-2.0	7/24	1 S				30	20	56	3	33		
	7/24	2 F			34	80	39	457	46	78		
244-116	7/23	1 F	17	12		25		1	2	19	106	
244-114-15	7/23	1 S				8	62	226	68	26		
244-114-9.0	7/25	2 S		4	37+*				5			89

* exceeding 75-100 per square foot

[3] includes Amphipoda, Arachnoidea, and Odonata

Appendix G, Continued

Clark Fork-Flathead Study Area

Station Mileage Indes	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
244-110	7/23		(no bottom samples obtained)									
244-102	7/23	2 F	11	1		21			1	16	67	2
244-73	7/17	2 S		1	14	2		1				
	8/28	1 S		17				8		6		4
	8/28	2 F		79		5	9	43		11		13
244-45-21	7/16	3 S			1	161	76	18	14	3	2	20
	8/27	2 S		3	11	52	88	203	10	105		16
244-45 19	7/16	1 S	5		250	101	24	5	10	58	11	20
	8/27	2 S		1	4	24	26	13		10		4
244-42-10-5.0	7/17	1 S	1	1	4	27	7	5	8	28		94
	7/17	1 F		5	22	36	1	49	13	17		25
	8/28	2 F	6	83	40	16	1	187	32	95		525
244-42-10-2.0	7/17	1 S	11	2	2	4		1	3	7		4
	7/17	1 F			4	2				9		
	8/28	2 F		4	32	28		4	7	234	5	1
244-20-9.0-6.0	7/22	1 S				11	62	3	4	55		1
	8/29	1 S			6	15	32	4	17	18	1	
	8/29	1 F		1	4	44	131	8	192	135		
244-20-9.0-3.0	7/22	1 S			9	17	51	5	36	11		
	8/29	1 S			7	2	30	5	23	9		
	8/29	1 F			15	8	42	94	305	18		
244-24-2.0	7/22	1 S				24	17	51		4		
	7/22	2 F				14	6	67	1	27		
	8/29	1 S				26	49	92	7	14		
	8/29	2 F			1	12	8	53	4	113		

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* exceeding 75-100 per square foot

[3] includes Amphipoda, Turbellaria, Arachnoidea, and Odonata

Appendix G, Continued

Clark Fork-Flathead Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
			Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
244-23	7/22	1 S			1		1			6		
	7/22	2 F			2	2	3	7	1	10		1
	8/29	1 S				2	30	7	6	86		1
	8/29	2 F				2	4	45	19	36		
240	7/11	1 S		4								
	7/11	2 F				3	10	7		8		
	8/15	2 F		6	1	4		161	6	4		7
235	7/11	1 S	7			1	1		12	7		2
	7/11	2 F			3	3		1		3		14
	8/15	1 S					6	41	1			
	8/15	2 F	30	1				4		2		
210	7/12		(impossible to obtain samples)									
205	7/12	1 S					1	3		1		
	7/12	2 F		1	1		11	70		3		
	8/15	2 F		7				6		2		

Kootenai Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
265	8/13	2 F		1	11	32	16	70	99	6	5	
262-9.0	8/13	2 F				102	113	141	5	224		
262-5.0	8/13	1 S				19	14	*	6	78		
	8/13	1 F				34	6	44		8		

* exceeding 75-100 per square foot

[3] includes Amphipoda, Nematoda, Turbellaria, Arachnoidea, and Odonata

Appendix G, Continued

Kootenai Study Area

Station Mileage Index	Date	Type & No. Of Samples Taken[1]	Total Numbers of Each Phylum, Class, or Order of Bottom Fauna Collected									
			Fish	Pul.	Olig.	Eph.	Plec.	Tric.	Col.	Dip.	Hem.	Other[3]
257	8/13	1 S		1		12	9	12	2	1		
	8/13	1 F		2	4	8	7	32		14		
204	8/14	1 S					1	1		8		
	8/14	1 F			4	6	7	22		21		
198	8/14	1 S				4	2	14		19		
	8/14	2 F		1	1	26	26	230		21		

Appendix H. Numbers of Bottom Fauna (Sensitive and Tolerant-Faculative to Pollution) and Number Of Samples Collected From Stations in the Clark Fork-Flathead-Kootenai Study Area During The Three Collection Periods of the 1957 Survey.

Surber Square-Foot Collections

Clark Fork-Flathead Study Area

STATION MILEAGE INDEX	FIRST COLLECTION PERIOD STARTING 6/25/57			SECOND COLLECTION PERIOD STARTING 7/26/57			THIRD COLLECTION PERIOD STARTING 8/26/57		
	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken
496	0	0	1	0	0	2			
476	0	0	1	0	0	2			
473				0	3	1			
472-4.0	36	46	1	22	220	1			
472-0.5				(no square foot-samples taken)					
469				(no square-foot samples taken)					
456	0	53	1	8	138	1			
452	0	*	1	0	57+*	1			
447	*	*	1	*	*	1			
445-2.0[1]	223	102	1	42	20	1			
443				13	43	1			
420	0	17	1	30	11	1			
418-26				(no square-foot samples taken)					
418-25				49	71	1			
418-24				90	272	1			
418-22				141	94	1			
418-13				136	91	1			
418-2.0[1]	310	165	1	19+*	6	1			
414	1	25	1						
386	204	22	1						
382-2.0[1]	90	10	1	33	5	1			
381	114	13	1	34	*	1			
369	21	58	1	65	26	1	24	35	1
365-2.0[1]				21	1	1	38	4	1
363				29	9	1	8	2	1
354				9	74	1			
352				29	20	1			
351-46				255	50	1			
351-40				18	7	1			

* exceeding 75-100 per square foot (computed as 100/sample for purposes of analysis)

[1] "Control Stations"

Surber Square-foot Collections

Clark Fork-Flathead Study Area

STATION MILEAGE INDEX	FIRST COLLECTION PERIOD STARTING 6/25/57			SECOND COLLECTION PERIOD STARTING 7/26/57			THIRD COLLECTION PERIOD STARTING 8/26/57		
	Sen. organ-isms	Tol. organ-isms	No. of samples taken	Sen. organ-isms	Tol. organ-isms	No. of samples taken	Sen. organ-isms	Tol. organ-isms	No. of samples taken
351-27							309	189	1
351-24				76	31	1	100	123	1
351-1.0[1]				144	14	1	15	10	1
349				91	18	1	49	21	1
342				45	7	1	104	50	1
338				66+2*	1	1	11	15	1
330				39	19	1	11	39	1
313				22	40	1	136	72	1
295				10+*	8	1	13	5	1
292	82	34	1				32	36	1
282	175	29	1				96	12	1
272	52	51	1				167	46	1
271-3.0[1]	203	72	1						
266	172	260	1				125	7	1
247	2	4	1				115+*	36	1
244-149-3.0				(no square-foot samples taken)					
244-143	2	0	1						
244-125	3	0	1						
244-123-2.0-15	25	69	1						
244-123-2.0-11				(no square-foot samples taken)					
244-123-2.0-2.0	106	36	1						
244-116				(no square-foot samples taken)					
244-114-15	296	94	1						
244-114-9.0	0	130+*	2						
244-110				(no bottom samples obtained)					
244-102				(no square-foot samples taken)					
244-73	3	15	2				8	27	1

* exceeding 75-100 per square foot (computed as 100/sample for purposes of analysis)
[1] "Control Stations"

Surber Square-Foot Collections

Clark Fork-Flathead Study Area

STATION MILEAGE INDEX	FIRST COLLECTION PERIOD STARTING 6/25/57			SECOND COLLECTION PERIOD STARTING 7/26/57			THIRD COLLECTION PERIOD STARTING 8/26/57		
	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken
244-45-21	255	40	3				359	129	2
244-45 19	130	354	1				67	15	2
244-42-10-5.0	40	135	1						
244-42-10-2.0	5	29	1						
244-20-9.0-6.0	76	60	1				51	42	1
244-20-9.0-3.0	73	56	1				37	39	1
244-24-2.0[1]	92	4	1				167	21	1
244-23	1	7	1				39	93	1
240	0	4	1						
235	11	19	1	47	1	1			
210				(impossible to obtain bottom samples)					
205	4	1	1						
Kootenai Study Area									
265				(no square-foot samples taken)					
262-9.0				(no square-foot samples taken)					
262-5.0				33+*	84	1			
257				36	4	1			
204				2	8	1			
198				20	19	1			

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* exceeding 75-100 per square foot (computed as 100/samples for purpose of analysis

[1] "Control Stations"

Clark Fork-Flathead Study Area

STATION MILEAGE INDEX	FIRST COLLECTION PERIOD STARTING 6/25/57 Sen. organ-isms	Tol. organ-isms	No. of samples taken	SECOND COLLECTION PERIOD STARTING 7/26/57 Sen. organ-isms	Tol. organ-isms	No. of samples taken	THIRD COLLECTION PERIOD STARTING 8/26/57 Sen. organ-isms	Tol. organ-isms	No. of samples taken
496	0	0	1						
476	0	0	1						
473	0	0	1	1	6	1			
472-4.0	143	69	1	22	164	1			
472-0.5	3	2+2*	1	0	300+*	1			
469	0	0	1	4	80	2			
456	2	94	1	65	176	2			
452				16	270+*	2			
447				322	320	2			
445-2.0[1]	317	150	2	89	65	1			
443	0	1+*	1	4	132	1			
420	0	15	1	34	111	2			
418-26				334+*	121	1			
418-25				93	91	2			
418-24				138	352	1			
418-22				175	140	2			
418-13				358	169	2			
418-2.0[1]	265+2*	97	2	64+*	126	1			
414	23	63	2	685	150+2*	2			
386	77	193	2	75	257	2			
382-2.0	156	20	2	359	71	2			
381	53	42	2	140	190	2			
369	28	122	2	65	150	2	294	274	2
365-2.0[1]	299	59	3	122	44	2	89	66	2
363	83	35	3	142	33	2	196	135	2
354	66	142	3	142+*	27	2	67	534	3
352	51	56	3	33	135	2	119	351	3
351-46				149	89	2			
351-40				589	95	2			
351-27				1046	297	2	834	251	2
351-24				507	272	2	401	268	2
351-1.0[1]				376	54	2	671	393	2
349	300	124	3	284	45	2	285	69	2

* exceeding 75-100 per square foot (computed as 100/sample for purpose of analysis)

[1] "Control Stations"

Four-square-Foot Collections

Clark Fork-Flathead Study Area

STATION MILEAGE INDEX	FIRST COLLECTION PERIOD STARTING 6/25/57			SECOND COLLECTION PERIOD STARTING 7/26/57			THIRD COLLECTION PERIOD STARTING 8/26/57		
	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken
342	101	63	3	462	42	2	811	184	2
338	174	255	3	195+3*	55	2	56	196	2
330	235	178	3	267	45	2	390	81	2
313	38	14	3	253+*	44	2	789	169	2
295	166	33	3	35+2*	24	2	2581	301	2
292	413	53	2				713	95	2
282	598	117	2				1198	22	2
272	137	21	2				1177	163	2
271-3.0[1]	45+*	18	1						
266	485	97	2				2519	31	2
247	206+2*	7	2				309	33	2
244-149-3.0	2	40	1						
244-143	32	6	2						
244-125	43	14	2						
244-123-2.0-15	135	82	2						
244-123-2.0-11	11	120+2*	2						
244-123-2.0-2.0	576	158	2						
244-116	43	139	1						
244-114-15				(no four-square-foot samples taken)					
244-114-9.0				(no four-square-foot samples taken)					
244-110				(no bottom samples obtained)					
244-102	32	87	2						
244-73							57	103	2
244-45-21				(no four-square-foot samples taken)					

* exceeding 75-100 per square foot (computed as 100/sample for purpose of analysis)

[1] "Control Stations"

Clark Fork-Flathead Study Area

STATION MILEAGE INDEX	FIRST COLLECTION PERIOD STARTING 6/25/57			SECOND COLLECTION PERIOD STARTING 7/26/57			THIRD COLLECTION PERIOD STARTING 8/26/57		
	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken	Sen. organisms	Tol. organisms	No. of samples taken
244-45-19				(no four-square-foot samples taken)					
244-42-10-5.0	86	82	1				210	775	2
244-42-10-2.0	2	13	1				32	283	2
244-20-9.0-6.0							183	332	1
244-20-9.0-3.0							144	338	1
244-24-2.0	87	28	2				73	118	2
244-23	13	13	2				51	55	2
240	20	8	2	172	17	2			
235	18	6	2	4	33	2			
210				(impossible to obtain samples)					
205	81	5	2	6	9	2			
Kootenai Study Area									
265				118	122	2			
262-9.0				356	229	2			
262-5.0				84	8	1			
257				47	20	1			
204				35	25	1			
198				282	23	2			